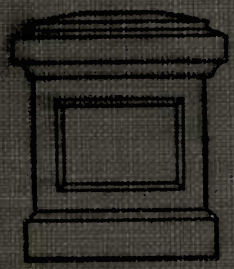
PRACTICAL CONCRETE WORK



CAMPBELL-BEYER

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Practical Concrete Work
for the
School and Home

By

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INTRODUCTION

Concrete has been the theme of many books. No excuse can be found for this one by claiming that the subject has not been written of before, yet the authors feel that there is a good excuse or reason for their efforts. While most of the volumes that have been written upon concrete are full of valuable information, the interested person has too frequently found that they contain but a little which really responds to *his interest.*

During the past two or three years concrete has occupied a place in the mind and doings of many people who previously knew or thought little of the subject or the material. Among these are thousands of school children in hundreds of vocational schools in various parts of the country, where enterprising instructors have looked abroad for new and untried yet practical subjects to add to their list and have chosen concrete work.

This little book has been prepared primarily as a workroom handbook for school shop use. Throughout the attempt has been to present those principles of good practice upon which depends the success of attempts at using concrete. The aim has been to write so anyone could understand. If that aim has been attained the authors will feel well repaid for their efforts.

Those who know the breadth of the subject, concrete, will realize that this little book falls far short of telling all that might be done with this wonderful modern building material. Enough has been told, however, to stimulate the interested person to look farther for more information. Much of this can be had for the asking; and no source of published information is better than the many leaflets and booklets published by the Portland Cement Association. Among them may be mentioned the following, which can be had upon request by addressing the Association at 111 West Washington Street, Chicago:

Concrete Silos.
Portland Cement Stucco.
Concrete Swimming and Wading Pools.
Fundamentals of Reinforced Concrete Design.
Suggested Specifications for Concrete Floors.
Protecting Concrete in Warm Weather.
Specifications for Concrete Roads, Streets and Alleys with Recommended Practice.
Concreting in Cold Weather.
Simple Forms for Concrete.
Tennis Every Day on Concrete Courts.
Concrete Septic Tanks.
Concrete Fence Posts.
Concrete Feeding Floors, Barnyard Pavements and Concrete Walks.
Proportioning Concrete Mixtures and Mixing and Placing Concrete.
Concrete Foundations.
Concrete Troughs, Tanks, Hog Wallows, Manure Pits and Cisterns.

Other books that the student or home worker may wish to see and read after he has finished with this little manual are the following:

Concrete Construction for Rural Communities. By Roy A. Seaton. McGraw-Hill Book Company, Inc., New York. $2.00.

Concrete on the Farm and in the Shop. By H. Colin Campbell. Norman W. Henley Publishing Company, New York. $0.75.

Concrete Pottery and Garden Furniture. By Ralph C. Davison. Munn and Company, Inc., New York. $1.50.

Farm Concrete. By K. J. T. Ekblaw. The Macmillan Company, New York. $1.75.

Limes and Cements; Their Nature, Manufacture and Uses. By Ernest A. Dancaster. D. Appleton and Company, New York. $1.75.

Popular Handbook for Cement and Concrete Users. By Myron H. Lewis and Albert H. Chandler. Norman W. Henley Publishing Company, New York. $2.50.

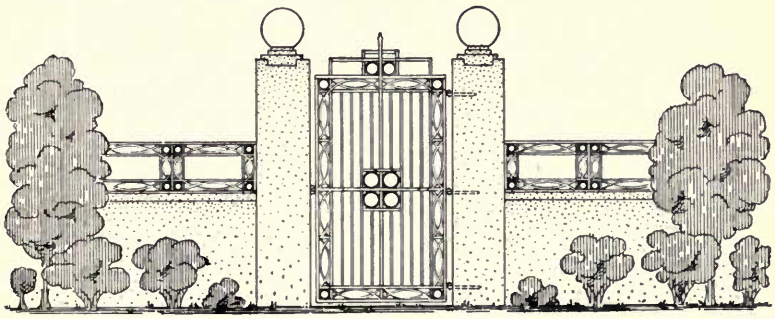
As even a simple use of concrete requires the application of certain fundamentals if the finished work is to be in every way a success, it will be clear that to arrange matter of this kind in the ordinary textbook form is practically impossible. The nearest approach to such an arrangement is evident in the last portion of this manual, where various designs for a number of concrete objects are presented in a logical order of progress as relates to the difficulty of making forms for these objects.

Hardly any subject other than concrete could be chosen for vocational shop work that would develop wood-working skill at the same time it discloses to the worker the possibilities of another material or medium of expression.

It is hoped that throughout this book there will be recognized a consistent effort to make it absolutely fit the title, "Practical Concrete Work for the School and Home."

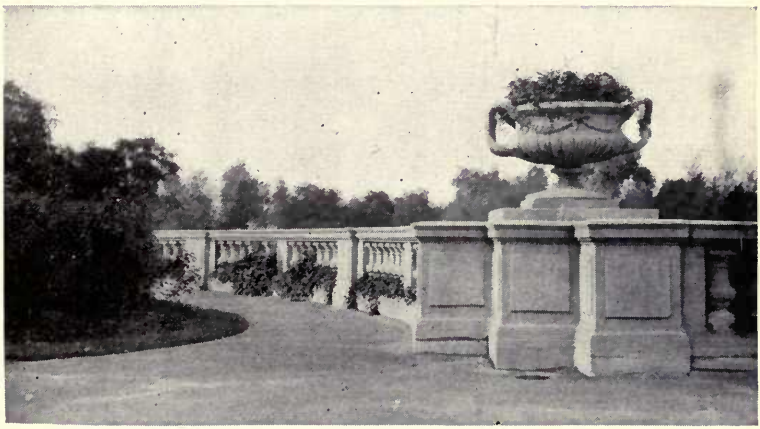
THE AUTHORS.

Chicago, September, 1917.



PRACTICAL CONCRETE WORK FOR THE SCHOOL AND HOME

What Concrete Is.—Concrete, in the sense in which we are to consider it, is an artificial stone made by combining portland cement, sand and pebbles (or broken stone) and water, and allowing the mixture to remain undisturbed until it has thoroughly hardened. This definition makes clear that concrete is a manufactured product, and being a manufactured product its quality is almost entirely in the hands of the



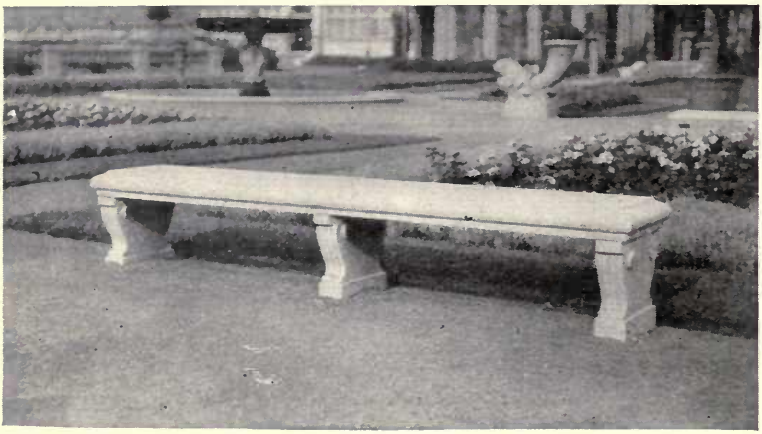
Ornamental fence and flower vase all of concrete, in which selected aggregates were used and the surface of the work rubbed down so as to expose these aggregates and give color to the surface.

manufacturer; that is, concrete will represent the skill or care used in selecting, combining, and using the materials of which it is made.

Concrete a Universal Building Material.—Today concrete enters in some way into practically every class of building construction, while there are more buildings now built of concrete throughout than ever before. Concrete possesses some wonderful possibilities. It is not in any sense a substi-

tute building material; things can be done with concrete or things built of it that are not possible with some of the older and once more common building materials, while practically everything can be done with concrete that any of the older building materials will permit.

To build right with any material, one must have a knowledge of its properties and possibilities. In the case of a manufactured building material, such as concrete, this means one must be familiar with the various materials of which it is



Concrete lawn bench made in imitation of granite by using white portland cement and selected granite chips, then rubbing the whole down with carborundum stone after forms were removed.

composed, and knowledge applied to select and use these materials so that the finished product—concrete—will be what is desired, and perform the purpose intended.

MATERIALS OF WHICH CONCRETE IS COMPOSED

Portland Cement.—First let us consider the materials of which concrete is composed. There are a number of kinds of cements or cementing materials, but in present-day reference to concrete work, usually portland cement only is considered. Portland cement is a manufactured product and was so named because of a resemblance in color which the first manufactured cement had to a stone quarried near Portland, England.

Portland cement will harden under or in the presence of water—in fact water is necessary to the proper hardening of portland cement, hence of concrete, because the cement is the active ingredient of concrete; that is, the cement is the binder or binding material which unites the sand and pebbles, or broken stone, into what eventually becomes solid stone.

Manufacture of Portland Cement.—The manufacture of portland cement is a scientific process. Briefly, portland cement is made by mixing definite proportions of limy and clayey materials and subjecting them to heat that almost causes them to melt—in other words, converts them into sort of a clinker or slag. After the materials have been kept at a degree of heat for a time sufficient to convert them into this clinker, the clinker is ground until it is reduced to a flour-like powder. This is portland cement.

In describing the fineness of grinding which portland cement must have to meet building construction requirements, it is customary to state the percentage of the powder which must pass through sieves having a certain number of meshes per square inch. Just before the process of manufacturing portland cement is considered complete, there is usually added to it and thoroughly mixed with it, a small quantity of some material (usually gypsum) to regulate the setting or hardening time.

To summarize the details of manufacturing portland cement, we might divide this process into five steps:

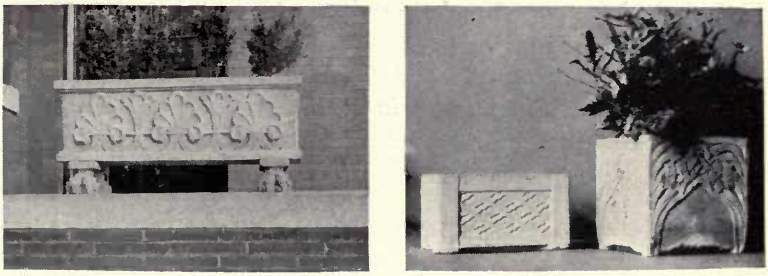
(1) Mining and quarrying the raw materials.
(2) Drying and grinding.
(3) Proportioning and mixing.
(4) Burning the mixed materials to a clinker.
(5) Grinding this clinker to an extremely fine powder and adding the proper quantity of some such material as gypsum, to control the setting or hardening of the cement when mixed with water.

Concrete sand boxes for the children to play in. Every home where there are children, and every school playground, should have one or more of these. When the children grow up, the boxes can be used for flower beds.

This summary of the steps of manufacture applies to that process known as the "dry" process. Cement is also manufactured after what are known as "wet" and "semiwet" processes. However, these details of manufacture are of no consequence to the student and will not be discussed.

Portland Cement a Product of High Quality.—Many persons think that when they have been unsuccessful with some attempt at concrete work, the cement was to blame. It is well to remember that portland cement is a manufactured

product and that its composition and qualities can be exactly controlled. If properly stored, portland cement is not susceptible to any great amount of change. Its quality is altered only by allowing it to be exposed to moisture. Moisture will ruin cement if it comes in contact with it before used in a concrete mixture. Portland cement is purposely made so that it will be acted upon by water in a manner to cause it to harden. This action, which takes place between the cement and water, is sort of a chemical one, and is usually described as "hydration." It is a process of crystallization. This is the change which produces the "set" or hardening of cement, or the hardening of concrete due to the set of the cement.



Two widely different types of flower boxes. To the right are simple small ones, while at the left is a large ornamental one used for window or balcony ornament.

Therefore in selecting portland cement to be used for making concrete, one can readily dismiss from his mind all thoughts as to the quality of the cement if he is careful to purchase any of the well-known brands and to purchase from a dealer who has good means for storing the cement so that it is protected from moisture. If when opening the sack and thrusting one's hand into it there are no lumps which cannot be broken by light pressure between the fingers, it is safe to say that the cement is in good condition. Lumps which cannot readily be broken in this way are probably due to the cement having absorbed moisture, which has caused the chemical changes leading to hardening. Such cement has lost most of its bind-

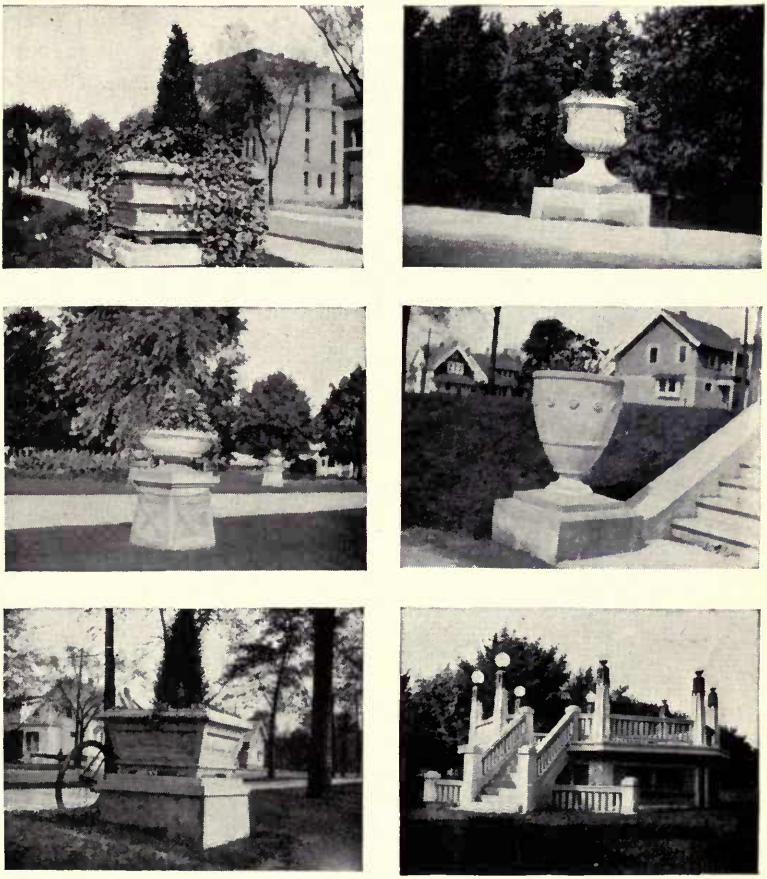
ing properties, therefore should not be used. Cement should therefore be stored in a tight, dry shed, never be piled on the ground but on a dry floor far enough above ground so dampness cannot be absorbed.

Aggregates—Sand and Pebbles or Broken Stone.—The strength of any structure cannot exceed that of the materials of which composed. A wood building is weakened if the timbers of which it is built are not of uniform strength throughout. Wherever a weak stick is used for a stud or post, that portion of the structure has less strength than where the material is uniformly of a higher grade. Nothing is more certain to produce unsatisfactory results in concrete work than aggregates which are not suited for use in concrete construction.

Aggregates Defined and Described—Sand.—Sand and pebbles or broken stone used in concrete mixtures are referred to as aggregates. The sand is known as fine aggregate. Pebbles and broken stone are called coarse aggregate. It is necessary to distinguish between sand and pebbles or broken stone by fixing some limits of size for these materials. It will be noticed that the term "pebbles" has been used instead of "gravel." Gravel, as ordinarily understood, means material taken from a natural bank or deposit composed of particles of all sizes ranging from dust to even small boulders. If we examine several such natural deposits, we will notice that there is no uniformity among them as to the quantities of fine and coarse materials contained. One pit or bank will be nearly all fine material—fine sand—while another may contain a large quantity of sand and pebbles mixed, and some stones several inches in diameter.

Sand is defined as that fine material free from clay, loam, vegetable, or other foreign matter, in which the particles range in size from ¼ inch downward to the smallest sized particles permissible, exclusive of dust. The maximum dimension of ¼ inch is fixed merely because it is convenient to start with

that dimension for defining coarse aggregate, which is pebbles or broken stone ranging in size from ¼ inch upward. A maximum size is fixed for coarse aggregate because it is not



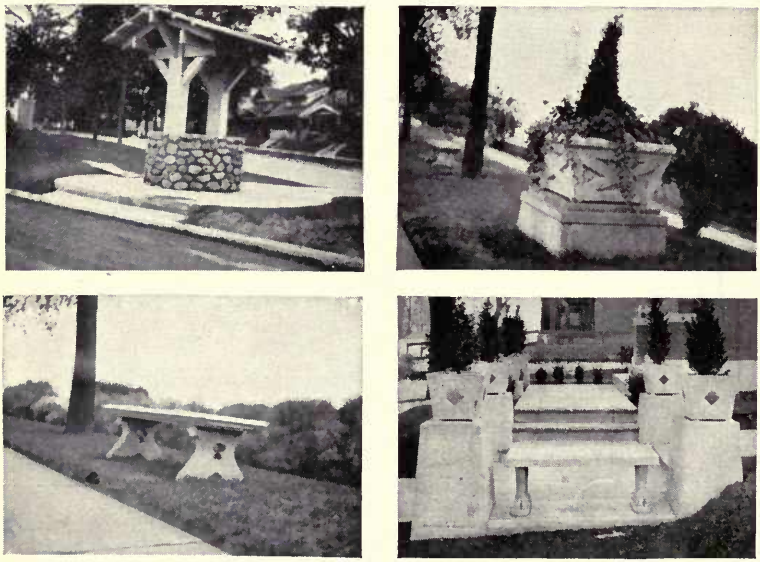
Several illustrations showing how concrete helps to ornament the home and park grounds.

convenient nor desirable in most concrete work to use pebbles or broken stone exceeding certain maximum dimensions.

Usually pebbles and broken stone are limited to 1¼ or 1½ inches in greatest dimension, but for most small objects ½ or not to exceed ¾ inch is the limit.

Grading of Sand and Pebbles.—Both fine and coarse aggregates must be well graded.

Voids, or Air Spaces in Sand or Pebbles.—Any volume of sand or pebbles contains voids, or air spaces, but if the material is graded by being composed of particles of different



A bench, some flower vases, and a well curb and platform. These well illustrate the range of use of concrete for such objects.

sizes, the lower will be the volume of these voids, or air spaces. In other words, voids, or air spaces, are greatly reduced in a given mass of sand or pebbles by proper grading of the particles. The same holds true of a given volume of broken stone. In this grading it is desirable that the coarser particles be in excess of fine particles. Just how this grading is accomplished by variation in the size of grains or particles

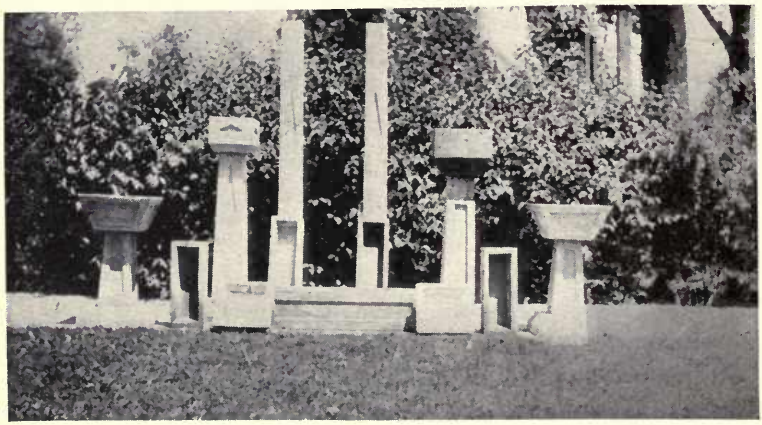
can be illustrated by drawing a series of circles to represent pebbles. It will be noticed that if we lay out a series of circles of uniform diameter, all touching one another, there will be spaces between them in which smaller circles may be drawn, also touching the others. After these have been drawn it will be possible to draw still smaller ones and so on. Imagining these circles to represent pebbles, one can see how the grading of particles in a mass of sand, pebbles or broken stone reduces the voids or air spaces, and will also see that the larger particles form the bulk of the mass. Sand thus graded, for example, presents a smaller area of surfaces than the same volume of fine sand, hence will require less cement to fill the few remaining voids and bond or bind the particles together. This point is brought out to show that it is true economy to go to some trouble to secure a graded sand, because of the saving in cement. This applies strictly to those uses of concrete associated with the usual building construction. There is an exception to the foregoing statement, which will be referred to again, and this exception applies more particularly to some of the concrete work to be described later. What has been said about grading of sand may be repeated as to the grading of pebbles or broken stone, that is, the coarse aggregate, because the requirements of grading for sand apply literally to the grading of pebbles or broken stone.

Bank-run Material.—In any volume of natural run of bank material in a so-called gravel pit, there will be voids, or air spaces, averaging somewhere around 45 per cent of the volume. Sometimes the volume of voids may be less, sometimes it may be more, but it is fair to consider 45 per cent the average that will be found in a series of tests for all kinds of bank-run material from all sources.

Origin of Sands and Pebbles.—Both fine and coarse aggregates should be selected with some regard as to the source from which they are derived, that is, the physical properties

of the materials. Sand and pebbles have different origins, that is, are of different kinds, depending upon the rock formation from which they originally came. The harder the rock, the better it is in general for concrete work. It will make a stronger concrete and one less subject to wear, if it is to be exposed to such usage as in walks, driveways, stable floors and other pavements.

Sand grains which can easily be crushed by rubbing between the palms of the hands or by slight pressure are



Some flower boxes, vases, pedestals and posts—work of manual training pupils with concrete.

not fit for use. These have probably had their origin in some shaly or clay-like rock and will not help to make a strong concrete. Quartz or flint sands, as a general rule, are preferable to all others. They contain less free mineral matter and the individual grains have great strength. Some sands have their origin in hard crystalline limestone. These also are excellent for use in concrete. Sometimes screenings from crushed stone that are clean and free from dust if graded from ¼ inch downward, are used the same as natural sand when making concrete. Any sand that contains clay, loam,

dirt, or similar matter should not be used until such foreign material has been removed by washing. This can readily be done in a number of ways, and simple equipment for the purpose will be illustrated and described later.

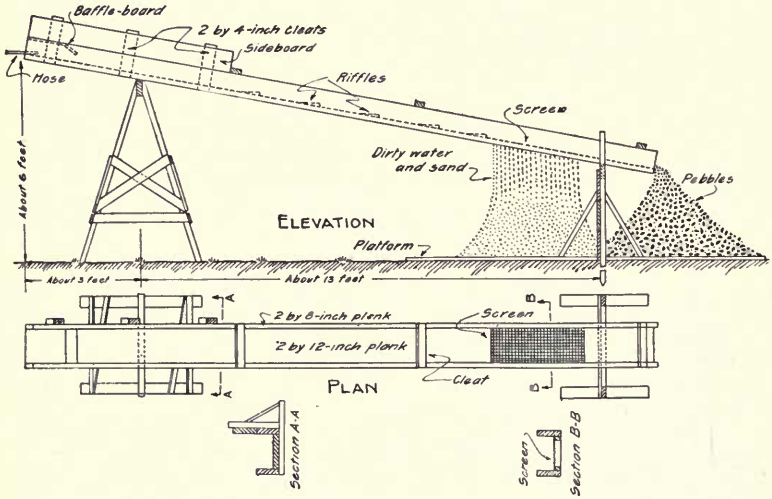
Pebbles or Broken Stone.—In selecting pebbles or broken stone for concrete, precautions similar to those outlined for the selection of sand should be followed. If pebbles are used instead of broken stone, they should be hard and durable in nature and should not be long and flat in shape. Such pieces do not compact solidly, so the concrete in which they might be used would not be so strong nor as dense as when the pebbles are nearly round or egg-shaped. When broken stone is used instead of pebbles, it should have been obtained by crushing some one of the hard, durable rocks such as granite, trap rock or a hard limestone. Some kinds of slag, which is the waste product from smelting iron ore, make a good coarse aggregate when crushed to proper sizes.

In selecting aggregates for concrete, one other thing should be borne in mind; that is, concrete is a wonderful fire-resisting material and its fire-resisting qualities can be greatly improved by selecting a hard, quartz-like, or siliceous sand, and a hard coarse aggregate like trap rock or slag, both of which have in nature, or from the source of their origin, been exposed to high heat, hence will stand such exposure in the concrete.

Clean Materials Necessary.—Attention has been called elsewhere to the necessity for using aggregates that are clean. Foreign matter such as clay is particularly objectionable when in the form of a coating on the particles. Where they are so coated, the cement cannot come in contact with the surface of the particles and therefore cannot bind them together.

Washing Materials Sometimes Necessary.—Where the only sand and pebbles obtainable contain foreign matter, it is necessary to wash them before using them in a concrete mixture. This can readily be done by building a trough

like shown below. Materials to be washed are shoveled into the trough at the high end, while water is applied at the same end through a hose connected to a pipe. Plenty of water flowing down the trough will cause the materials to be

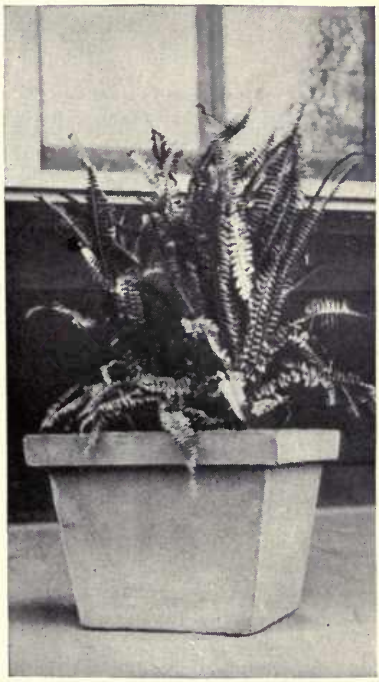


A simple home-made device for washing sand and pebbles and for separating the two from each other.

cleaned by tumbling and rolling about. At the lower end a screen is placed to separate the sand from the pebbles. The water carries off the foreign material. Wedge-shaped cleats (riffles) are nailed on the bottom of the trough inside to assist in tumbling the materials as they roll down.

The foregoing description of aggregates and their physical and other requirements to fit them for use in concrete work applies particularly to the broad applications of concrete in building construction. There is another aspect of the subject of aggregates which pertains particularly to the use of concrete in the making of some small ornamental objects or wares, none of which is to be subjected to such tests of strength as is demanded of concrete in certain portions of

buildings. For instance, a concrete window flower box need not have any more strength than necessary to protect it from the action of the elements or from possible breakage due to occasional handling. Therefore the permissible requirements of aggregates may be modified somewhat in applying them to school or home work for some small objects. For instance, it is much easier to secure a smooth surface on a concrete flower box or a vase, if the coarse aggregate is omitted entirely and a slight excess of cement used with sand only—the sand, of course, being properly graded. It is possible to give a very attractive surface finish to concrete work in a number of ways, some of which are controlled entirely by selecting aggregate in which the particles are all of uniform size or nearly so, and then treating this surface in a number of ways which will be described later.

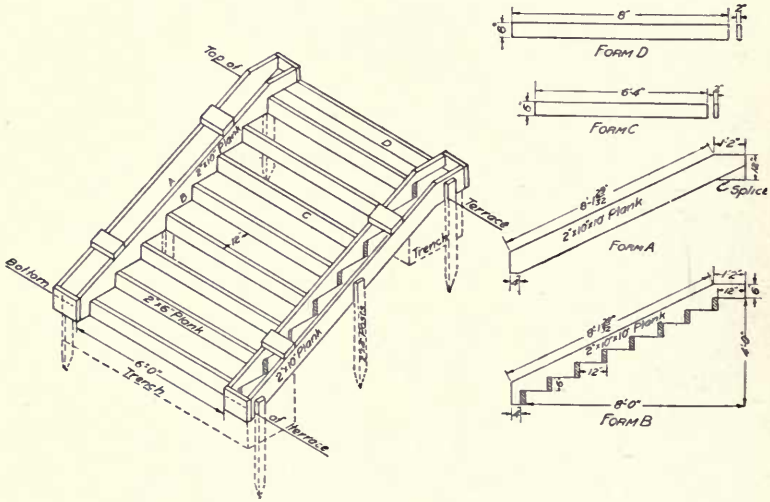


A simple easily made concrete fern box.

Pure, Clean Water Necessary.—The water used in concrete mixtures must be pure and clean. It should not contain acid, oil nor alkali, nor be cloudy, due to the presence of clay, loam, silt or similar matter in suspension. It should be good enough to drink. If it is of such quality, it will be best for concrete.

FORMS FOR CONCRETE WORK

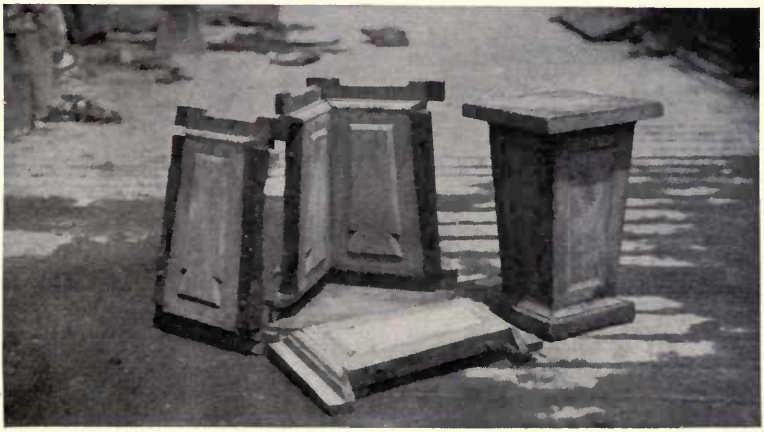
General.—To use concrete in making any object, it is necessary that the material, while in a plastic state, be confined in some form or mold which has an interior surface and shape corresponding to that of the object which is to be made. Therefore forms or molds are the receptacles in which a concrete mixture is placed immediately after mixing so that when hardened the concrete will assume the shape desired or intended.



Forms for concrete steps. Care should be taken to have the ground well compacted where steps are to rest. The side walls, or ramps, can be made first or last as desired. A 1:2:4 concrete mixture should be used throughout. The concrete should be wood floated on the step treads instead of finished with a steel trowel. Using a wood float will give a surface that will provide a good foothold.

Types of Forms.—Forms for concrete may be made wholly of wood, or of wood metal lined, or wholly of metal, or in some cases of plaster of Paris. By far the greater number of forms used in concrete work are made of wood. Cast iron and steel forms or molds are used in connection with machines that make concrete block, concrete brick, and similar concrete

objects that are made wholly or in part by compressing the concrete mixture. Also, metal molds or wood molds metal lined are used in cases where it is desired to give the concrete a particularly smooth surface. The shape of forms is governed entirely by the shape of the object which it is desired to build. Form work is a very important step in the use of concrete for any building construction. No concrete object can be truer in shape or form than the mold in which it is made, and for small objects or those which are to be somewhat

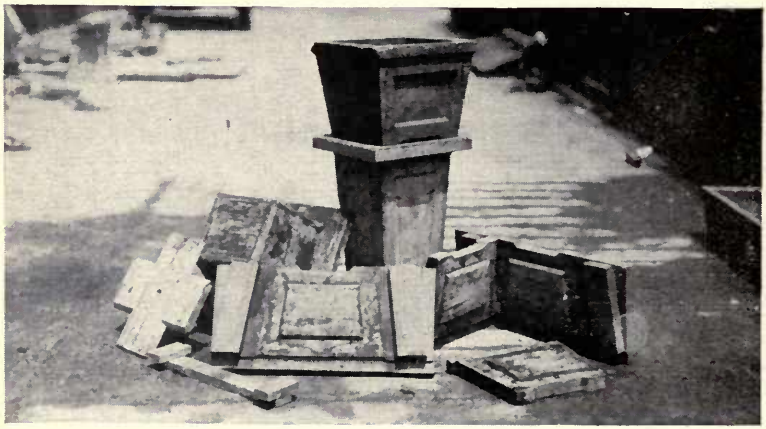


Forms removed from a concrete pedestal to illustrate both forms and finished object.

ornamental, careful work done on forms is well repaid in the satisfaction given by the finished concrete work.

Some Form Requirements.—When wood is used for concrete forms it is necessary that it be straight-grained material free from warp, knots and other imperfections which would leave their imprint on the finished concrete surface, for concrete is very faithful in reproducing both the perfection as well as the imperfection or irregularity of forms. For ordinary concrete work such as foundation walls and surfaces which are not to be permanently exposed to view and hence

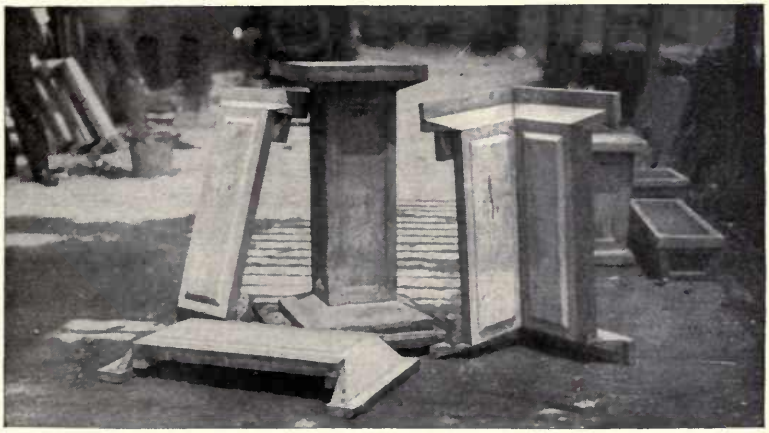
which need not have that smooth, regular finish otherwise desirable, common grades of lumber may be used provided the material has the required strength. Spruce, Norway pine and southern pine are used largely in such cases. Whether the lumber shall be planed on one side and two edges depends somewhat on the nature of the work. A planed surface can be treated so that little concrete will stick to it, while planed or jointed edges of form boards make tight-fitting forms which prevent joint markings on the work and any leakage of



Forms removed from vase and pedestal in which they were made.

cement and water from the concrete. White pine is often used for small objects, especially where some ornament is to be added, because it is easy to work. Except in such cases, however, it is usually a more expensive form material than is required. Cast iron, sheet steel, or wood covered with galvanized iron or sheet steel is used where an extremely smooth finish is desired without further treatment after forms have been removed from the work. Forms made of metal can be cleaned more easily than wood forms and can be used a greater number of times.

One of the pleasurable aspects of concrete work to many is that it requires that there be skill in carpenter work. It gives a person the opportunity to display individuality in more ways than one. Forms should be carefully planned so that there may be no difficulty in assembling the pieces nor in taking them from the object when finished. Careful planning will also result in considerable saving of lumber because much unnecessary cutting and waste will be avoided. Wherever possible, forms should be planned so that for use they



Another example of concrete pedestal showing the forms in which it was made.

can be assembled with few and simple fastenings. Screws and clamps to hold them together while concrete is being placed—where they can be used—are preferable to nails or other permanent methods of assembling.

Air-seasoned lumber is better than kiln-dried for ordinary form purposes, but for small objects and especially for objects that are to have some ornament, kiln-dried lumber should be used and the lumber should be given special treatment before assembled the first time so as to prevent changes in its shape or form due to swelling and warping because of alternate wet

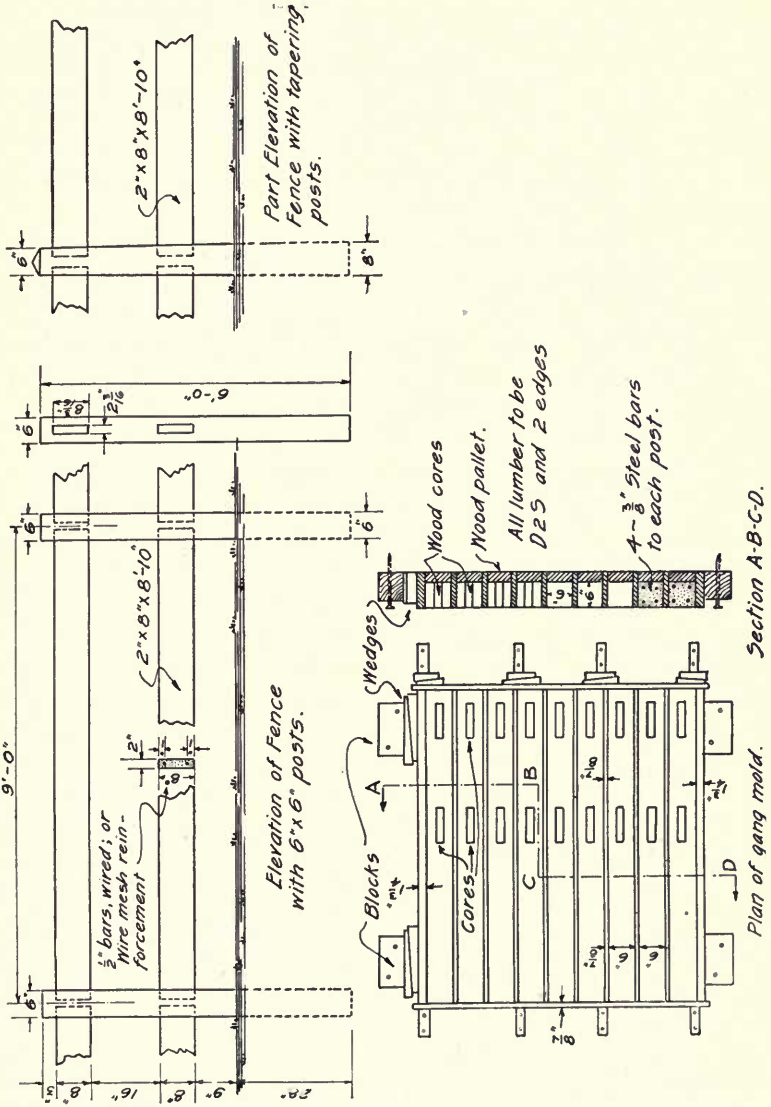
and dry conditions in use. For many of the small objects that will be illustrated and described later, clear, kiln-dried white pine will be the best lumber to use for forms.

Soaking Forms in Oil.—After the various parts have been cut to proper shape and dimensions, each should be treated with crude oil or a mixture of equal parts of linseed oil and kerosene, so that the lumber will be thoroughly saturated and hence will repel water. This can be done by making a shallow galvanized iron box or tray sufficiently large to receive the longest pieces or parts that will ever be used and allowing these pieces to lie in the oil until they will absorb no more. Then when used, if the form surfaces next to the concrete are wiped with a piece of oily waste and thoroughly cleaned each time after use, it will be found that the forms will not undergo changes in shape that will make them bind when putting together or taking apart. In this way wood forms will also be made more durable. They will serve for repeated use where otherwise their usefulness would end after being filled a few times only.

Another method of treating forms to prevent concrete from sticking to them and to prolong their usefulness is to apply several coats of hot paraffin by painting on with a brush. This method of treatment, however, is more expensive than soaking in crude oil and is no more effective.

Cleaning Forms After Use.—Each time after use, forms should be carefully cleaned. Some particles of concrete are quite likely to adhere to the surface and unless this is removed and the surface carefully wiped with a rag or piece of cotton waste soaked with crude oil or the kerosene-linseed oil mixture mentioned, form removal will be difficult and imperfections will appear on the surface of the concrete product.

Forms Must Be Tight.—Forms must be strong enough to hold the weight of the concrete without bulging out of shape and must be clamped or otherwise secured together when in



Design for reinforced concrete panel fence. Posts and panels are cast separately, then assembled as shown. This sketch also shows in detail the forms required for building the posts.

use, to withstand tendency to bulge while the concrete is being rammed or packed in the molds.

Dressed lumber is necessary where smooth surface finish is desired. Joints must be tight to prevent water from carrying cement from the forms and thus robbing the concrete of its most desirable ingredient. Where boards are used for sheathing on studs such as on a form for a foundation wall, the sheathing boards should be uniform in thickness to prevent unevenness or irregularities on the concrete surface. Posts and studs used for supporting or bracing forms for building walls must also be stiff and strong enough to hold the forms in true line and to prevent sagging when the load of concrete is placed.

Metal Forms and Ornament.—Cast iron forms for ornamental products are frequently used. These are cast in a foundry from wood patterns made for that purpose. The degree of ornament that can be given to any concrete work depends largely upon the skill of the wood worker who makes the pattern from which a cast iron form is cast.

Commercial Forms.—Except for the practice obtained in woodworking and for the pleasure of doing the work, it does not pay to attempt to manufacture concrete molds for some kinds of objects. This is particularly true of forms for concrete block, concrete brick, plain concrete fence posts, etc. By far more satisfactory results can be obtained when making these products if some one of the many commercial molds now on the market is used.

Proper Planning of Forms.—Planning forms or molds for ornamental objects so that they may be removed from the object without injury to it requires in some instances considerable forethought. Division points must be along such lines as to give the least resistance or friction when removing parts of the form. At no point should any section of the form bind or cling to a projecting part of the concrete object, as the least sticking to the concrete makes it likely that a portion of the

surface will be marred or broken. Molds for fluted columns, for instance, may have to be divided into eight or more sections so that they can be removed without injury to the concrete. Even the mold for a cylindrical object may have to be divided into three or more parts. There is no possibility of injuring the product when removing such a form from the concrete if the form has been properly divided. If a form of this kind were to be divided merely into two parts, it is possible that the division line would not make the supposed halves equal, hence one section would bind or cling to the cast. This applies with but few exceptions to all circular molds. As the average projections can be planned so that the greatest length will come at a division point or in such a position between division points that the mold will not cling when removed, such planning should be a part of the form construction. Cores for objects that are hollow must be planned so that they also can be readily withdrawn without hammering or pounding or without exerting any force on the object that might tend to burst it while the concrete is soft.

Examples of Division of Forms.—Elsewhere are examples illustrating the points just brought out and showing how forms must be planned so that the various sections will part from the concrete without injuring it.

CONCRETING TOOLS AND EQUIPMENT

Tools Commonly Required.—Most of the tools required in concrete work are simple and many of them can be home made. The principal ones are the following:

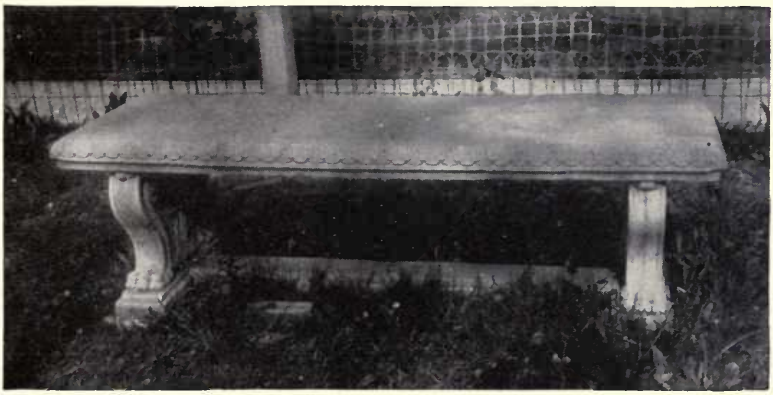
Screen.
Mixing platform.
Square pointed shovels.
Measuring box.
Water barrel.
Pails.
Hose.
Tamper.
Spading tool.
Strikeboard.
Wood float.
Steel trowel.
Edger.
Groover.
Wheelbarrow.

Screen.—A sand screen should be 2 feet 6 inches or 3 feet wide, and 6 feet long. The frame may be made of 1½ or 2-inch lumber, 4 to 6 inches wide. Legs should be so attached to the sides that the screen can be set at the desired angle while throwing material upon it to separate the sand from the pebbles. This angle should be about 45 degrees. A piece of wire cloth or fabric should be nailed to the frame. This may be either ⅜-inch slotted screen wire with cross wires from 4 to 6 inches apart or a woven wire fabric having 4 meshes to the linear inch (16 to the square inch). Material to be screened is thrown in shovelfuls against the upper portion of the screen and in rolling down, the sand and pebbles are separated.

Mixing Platform.—A mixing platform may be made by using a piece of sheet steel about ⅛ inch thick with 2 by 4's set on edge and properly fastened to three of the four edges or sides of the steel; or the platform can be made entirely of wood. In this case the floor of the platform should be of not less than 1½-inch lumber, 4 to 6 inches wide, tongued and grooved, and surfaced on the side that is to be uppermost, that is, the side upon which mixing is done. This will make it easy to shovel materials. If tongued and grooved lumber

is not obtainable, the edges of the boards should be planed or jointed so that they can be nailed closely together on 3 by 4 or 4 by 4-inch stringers, placed two or more feet apart, to make a firm, unyielding platform upon which to work. Two by 4 strips should be nailed to three sides so that when shoveling materials in mixing, they will not be shoveled off the board.

Measuring Box.—The measuring box is necessary to measure exact quantities of sand and pebbles or broken stone.



Concrete lawn bench with considerable ornament.

Such a box is a bottomless frame made of 1 or 1½-inch material and should have a capacity not less than 1 cubic foot. If larger, then it should be of 2, 3 or 4 cubic feet capacity and should be marked on the inside so that at certain levels the markings will show volumes of 1, 2, 3, etc., cubic feet. Handles are placed on the sides of the box to make lifting easy after the material required has been measured.

Shovels.—For mixing concrete, ordinary square pointed shovels are used. These are familiar objects to everyone and need no description.

Water Barrel, Pails and Hose.—A water barrel and pails or a hose are necessary to add the required amount of water to the correctly measured materials.

Wheelbarrow.—For transferring concrete from the mixer or mixing platform to the place of final use, a wheelbarrow may be needed. One with a sheet iron body should be used having the front of the body higher than the back, to prevent loss of concrete when the barrow handles are raised in position for wheeling.

Tamper.—When placing concrete in the forms, it must be spaded or tamped, depending upon the quantity of water used in the mixture (recommended consistencies for mixtures will be described later). A tamper may be home made by boring a 1½-inch hole in the end of an 8 by 8 by 12-inch piece of timber and inserting a handle about 4 feet long in the hole. Metal tampers 6 to 8 inches square may also be used. Several commercial kinds are obtainable.

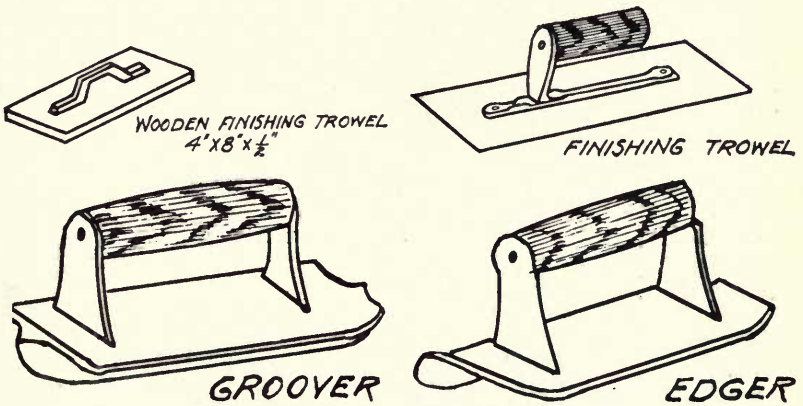
Spading Tools.—A spading tool of some kind is necessary when placing concrete of a certain consistency to properly settle the material in the forms and also to secure a surface finish free from pebble pockets. Such a spading tool may be made by flattening an ordinary garden spade and cutting out portions of the metal so that it is slotted, or by straightening out an old garden hoe. Both tools are used by working them up and down in the concrete close to form faces so as to force back coarse particles and thus cause the sand-cement mortar to come to the form face.

Sometimes a chisel-edged board 4 to 6 inches wide may be used for spading concrete, the upper end being properly shaped to form a convenient handle. In other cases, especially where reinforcing metal is placed in the concrete, smaller spading tools will be needed to work in the smaller space or between sections in which the concrete is placed. Pointed sticks, steel rods, or narrow chisel-edged pieces of wood are used for this purpose.

Strikeboard.—A strikeboard is merely a piece of 1½ or 2-inch lumber 4 inches or more wide and long enough to rest across the top of the forms, as in sidewalk construction, so that the top of the concrete can be approximately leveled before final finishing.

Wood Float.—A wood float is used to finish the surface of the concrete after struck off, as in building walks, pavements and floors. This is a simple tool and can be made by anyone.

Steel Trowel.—A steel hand float or trowel may sometimes be required where a smoother surface is desired than can be obtained by using the wood float. However, care should be taken not to trowel a surface too much with a steel trowel, as such practice brings an excess of cement to the surface and makes it less durable. A steel troweled surface is also likely to be slippery and not provide as secure a foothold as the wood floated surface.



Several common concrete finishing tools.

Groover and Edger.—For finishing joints between slabs in walk, floor and similar concrete pavement work, a tool known as a groover is used, while for finishing the edges of the slabs the tool used is known as an edger.

Power Mixer.—The foregoing are the principal tools required for the average run of concrete work. When any considerable quantity of concrete is to be mixed, mixing may be done more thoroughly and economically by using a power-operated mixer. Power-operated mixers should be of the batch type, that is, a machine in which all of the materials for a batch of concrete are measured and placed in the drum or cylinder of the machine at once and mixed as a batch instead of as a continuous, uninterrupted operation. In this way all batches of concrete are uniform in proportions and consistency. Many types and sizes of power-operated concrete mixers are on the market. Several manufacturers of concrete mixers make machines that are relatively cheap and at the same time very efficient.

A concrete fountain makes an attractive and permanent fixture for the home grounds. Designs elsewhere in this book show form construction for such ornaments.

PRINCIPLES OF REINFORCING

Reason for Reinforcing Concrete.—When concrete was first employed as a building material its use was confined principally to plain, massive work such as footings and foundations, in just the same way as stone masonry is used. Concrete is very strong when used in mass work where the load is placed immediately upon it, that is, where the load is one of compression; but like most building stones, concrete is relatively weak in tension, that is, in resisting strains or loads that tend to bend it or pull it apart. This fact was known long ago and resulted in attempts being made in the latter fifties or early sixties to give concrete added strength in tension by embedding in it some kind of metal. Placing metal in concrete in this way for the purpose mentioned is called reinforcing the concrete. Reinforced concrete permits more economical use of concrete and at the same time is considerably stronger than plain concrete, that is, concrete without any reinforcing metal in it.

The strength of concrete in compression is about ten times that of its strength in tension. The full tensile strength which concrete possesses is taken advantage of by properly reinforcing it.

Not every kind of metal or material will do for reinforcement in concrete. Usually some kind of steel is specified, that is, one having a certain chemical composition and other properties. The steel, if properly embedded in concrete of correct proportions and consistency, so that everywhere the concrete will bond or adhere perfectly to the metal, takes the pulling and bending strains because the adhesion between the concrete and the steel prevents the steel from slipping. These facts make it possible to use concrete in many ways that would be impracticable were it not reinforced. Therefore we may define reinforced concrete as a combination of concrete and metal (preferably steel of certain quality), the metal being so placed as regards position and quantity that

the concrete and the metal both take and resist the strains which they can best withstand.

Practical Illustration of the Principles of Reinforcing.—It is not practicable in the limited space of this section to go into the technical details of reinforcing concrete, because the subject of concrete design is one that requires considerable knowledge of advanced mathematics and its application to structural design. The descriptions of most of the designs illustrated later in this book include recommendations as to proper reinforcing of the object.

Two or three simple examples will help the reader to understand the principles of reinforced concrete.

An accompanying figure is intended to illustrate a beam made of two pieces connected by a hinge. In the top of the hinged joint is supposed to be a block of rubber; at the bottom is a coiled spring. When a load is placed on top of the beam it will, of course, bend at the hinged joint. One can readily see that supported as it is at the two ends, this bending tends to close the gap at the top where the piece of rubber

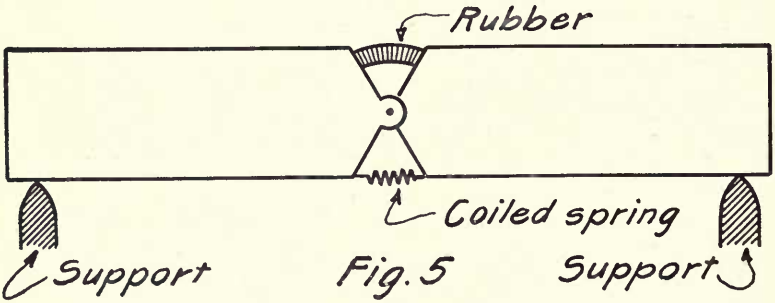


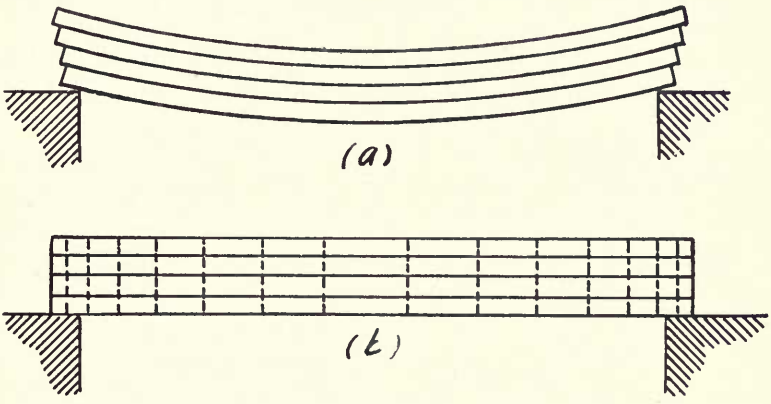
Fig. 5

Sketch illustrating the action of a load on a concrete beam supported at each end.

is inserted and to make the gap at the bottom widen where the coiled spring is inserted—in other words, the rubber will be compressed while the spring will be stretched. At the same time the spring will receive a pulling strain and will have a

tendency to resist the bending. Now if instead of being broken and hinged as shown, the beam were made solid, and if instead of the coiled spring a steel rod were embedded in the concrete, say, ½ inch or more from the lower face of the beam, the adhesion between the concrete and the steel would compel the steel to resist the tendency toward bending—in other words, would take up the tensile strain which is exerted by the load, whatever it may be, that is placed upon the beam.

Another example is given in another illustration, which also shows the manner in which bending strains on a concrete beam act and may be resisted. At (a) there are supposed to be illustrated several planks or boards laid one on top of the other and supported at their ends. Any load placed upon them will cause them to bend, and the slipping of one plank past



Planks or boards before and after bolted together, showing the effect which reinforcement has in a concrete beam, for instance.

or along the adjoining plank is a horizontal movement. If the planks or boards are bolted together as shown at (b), this slipping cannot occur. In reinforced concrete beams, rods, with what are called stirrups, properly connected to and ex-

tending from these rods up in the beam, will take care of the same strains in the concrete as are illustrated at (a) in the planks under load.

The principal reason why steel is used as reinforcement for concrete is that steel and concrete expand and contract under changes of temperature (as do all materials) in about the same degree or ratio. This is very necessary as it prevents the bond or adhesion between the concrete and the steel from being broken.

Steel is placed in the concrete where it will best resist the tensile strains. By referring to the illustration, in which the hinged beam is shown, it should be easy to see that the best place for the steel would be not at the center of the beam but either along the outside lower face or as near to it as possible. If the steel were left exposed, it would eventually rust, while if the concrete were exposed to severe fire the steel might be injured from such exposure, therefore it is embedded in the concrete as near to the lower outer surface as possible, yet sufficiently deep to be surrounded with enough concrete to protect against corrosion, such as rust, and against exposure to fire.

A beam of concrete or of stone could be made long enough so that without reinforcement and supported at its ends or at one end only, its own weight would cause it to break. If steel is properly placed in the concrete, however, not only may the length of such a beam be increased without danger of breaking but it can be made to support considerable load in addition to its own weight.

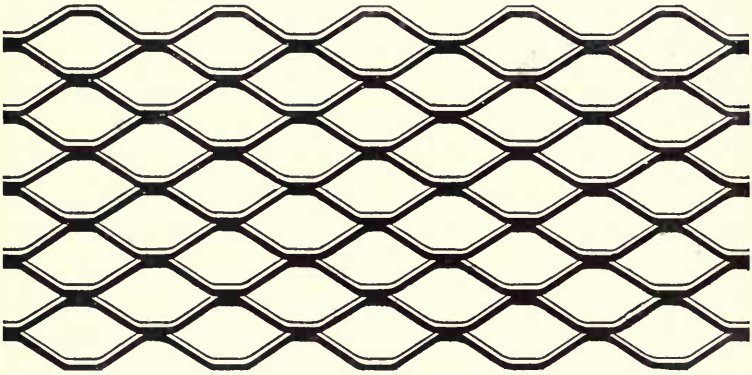
Reinforcing a Post or Column.—A column or fence post should be so reinforced that it will resist tension on all sides because in a fence post, for example, as it is set in a fence line, pulling strains may come upon it from any one of four directions. Animals might try to break in or out of the enclosure. Strain of the wires may come from either direction along the fence line, and as one cannot tell just how the

fence post may be required to act, it is necessary to place reinforcing rods at each of the four corners of the square or rectangular fence post and at positions corresponding to a square in a circular post. Rods should be placed just as near the surface as possible and at the same time permit thoroughly surrounding them with concrete.

Example of Column Loading.—The strains that are brought to bear upon a loaded column may be illustrated in a simple manner. Suppose we make a cylinder of tissue paper and fill it with sand. If handled carefully the tissue paper will withstand the tendency of the sand to burst the paper and spread itself out in a pyramidal pile. If slight pressure from one's hand is applied to the top of the filled paper cylinder, the compacting of the sand will cause it to burst the tissue paper. If the cylinder is made of tin, we can readily see that it would require a great deal more pressure than one could exert by hand to break the tin. Going a step farther and taking a concrete column instead of the cylinder of sand, we can realize that if hoops of steel are properly embedded in the concrete as reinforcement, they will act in a manner similar to the tin cylinder in preventing the sand from bursting it.

Reinforcing Materials.—As already mentioned, not every kind of material nor every kind of steel is suited for reinforcing concrete. Generally speaking, some types of round or square twisted steel rods or bars are used more extensively for reinforcing concrete than any other material. Next to these perhaps are some of the mesh fabrics and so-called expanded metals. Various kinds of patented bars are on the market. Most of these involve some alteration of the shape of the bar, such as forming lugs or projections on it while rolling the metal and in this way attempting to prevent any slipping of the steel in the concrete—in other words, increasing the mechanical bond. Tests have shown, however, that if concrete is properly proportioned and of the right consistency

and properly placed, few if any of these patented types of bars have anything to recommend them for choice in the ordinary classes of concrete construction.



One of several types of expanded metal used as reinforcement for concrete.

Many of the reinforcing fabrics are similar to certain types of woven wire fencing with the exception, however, that the meshes or openings in them are of uniform size throughout the width and length of the material. Expanded metal is made by slotting or cutting thin sheets of steel and then stretching or drawing the sheets so as to increase their area or "expand" them, thus forming a sort of a fabric. The advantage of many of these metal fabrics and expanded metals is readily apparent in such work as stucco or plastered surfaces. They provide a good bond or key for the cement mortar plaster and are also fireproof and practically permanent. Many of the mesh fabrics or different types of expanded metal are particularly suited to reinforcing some of the concrete work illustrated and described in this book.

Scrap Wire and Metal Not Suitable for Reinforcement.—Any attempt to substitute barbed wire, old scrap iron, pipes or similar odds and ends of scrap metal, will not result in the same success and security of construction as will follow the use of proper reinforcing materials.

Round bars will be found easiest to obtain under most conditions and will be suited to the general run of home or school concrete work. One should remember that the steel or iron bars which he may be able to obtain from the local blacksmith shop will not necessarily have the desired quality for the structural demands in concrete construction. For such work it is best to purchase reinforcing steel from some dealer or manufacturer making a specialty of such materials.

Sometimes poultry netting may be used as reinforcement for small flower boxes and similar objects. A netting of 1-inch mesh made of No. 19 gage wire will be found to meet average requirements.

When it is necessary to splice reinforcing, either rods or netting, care must be taken that this is done in a way to get the effect of the metal, that is, so that the tensile strains may at once be taken by it and not by the concrete. Ends of netting should be lapped at least 4 inches and bound together securely by wires. Rods should be lapped from 50 to 60 times their diameter. Reinforcing metal should be kept clean until used. Any coating of scaly rust or mill scale or a coating of oil will prevent the concrete from adhering to it.

Concrete tennis courts have long been popular, although not everywhere common.

PROPORTIONING CONCRETE MIXTURES

Principles of Proportioning.—With suitable materials selected for any concrete work, the next step is to correctly proportion them. Different classes of concrete work require that for best results the mixtures used shall vary somewhat in the proportions of portland cement, sand or stone screenings, and pebbles or broken stone used. Certain proportions may be thoroughly satisfactory for one kind of concrete work or for one portion of a building, yet not be at all suited for other work or for some other portion of the same building. In proportioning concrete mixtures the aim is to use enough cement to fill all the voids or air spaces in the sand and enough sand-cement mortar to fill all the air spaces in the bulk of pebbles or broken stone.

In most buildings the foundations must contain a certain mass of concrete. If there is to be no cellar enclosed by the foundation wall, watertightness of the concrete is not absolutely necessary, so a mixture containing less cement may sometimes answer. But if watertightness is one of the essentials, the concrete should be very carefully proportioned and have sufficient cement in it to fill all the air spaces or voids in the mixed sand and pebbles so as to prevent water from leaking through the foundation. Watertight concrete comes from well graded materials properly proportioned with enough cement, all well mixed to the right consistency, properly placed, and not allowed to dry out after placing. Some classes of concrete work need not be as strong as others. In such cases also a mixture containing less cement may be used.

Arbitrary Mixtures.—The proportioning of concrete materials where great exactness is required may involve numerous and somewhat complicated tests of the sand and pebbles or broken stone. In the average run of concrete work such exact methods or determinations are not necessary and it is common to proportion concrete mixtures after somewhat arbitrary methods that have become fixed usually as a result of experi-

ence in various classes of work having proved such mixtures satisfactory. These arbitrary methods usually show that a similar ratio is maintained between the quantity of sand and pebbles or broken stone used, while the ratio of cement to the other ingredient is reduced, depending upon the degree of strength, watertightness or density of concrete necessary. Therefore, in most recommended concrete mixtures the bulk of pebbles or broken stone used is approximately twice that of the sand. A table of arbitrary mixtures follows. Suggestions are given under each mixture proposed, that will enable selection of one suited to the class of concrete work contemplated.

QUANTITIES OF MATERIALS REQUIRED FOR VARIOUS MIXTURES OF MORTAR AND CONCRETE

MIXTURE MATERIALS FOR ONE BAG BATCH				RESULTING VOLUME IN CUBIC FEET		QUANTITIES OF CEMENT, SAND, AND PEBBLES OR STONE REQUIRED FOR ONE CUBIC YARD OF COMPACTED MORTAR OR CONCRETE				
	Cement in Sacks	Sand cu. ft.	Pebbles or Stone cu. ft.	Mortar	Concrete	Cement in Sacks	Sand		Stone or Pebbles	
							Cu. Ft	Cu. Yd.	Cu. Ft.	Cu. Yd.
1:1½	1	1.5		1.75		15.5	23.2	.86		
1:2	1	2.0		2.1		12.8	25.6	.95		
1:2½	1	2.5		2.5		11.0	27.5	1.02		
1:3	1	3.0		2.8		9.6	28.8	1.07		
1:2:3	1	2.0	3.0		3.9	7.0	14.0	.52	21.0	.78
1:2:4	1	2.0	4.0		4.5	6.0	12.0	.44	24.0	.89
1:2½:4	1	2.5	4.0		4.8	5.6	14.0	.52	22.4	.83
1:2½:5	1	2.5	5.0		5.4	5.0	12.5	.46	25.0	.92
1:3:6	1	3.0	6.0		6.4	4.2	12.6	.47	25.2	.94

(Based on tables in "Concrete, Plain and Reinforced," by Taylor & Thompson)

(NOTE: Concrete mixtures are generally proportioned by volume. A 1:1:1 mixture means 1 sack of portland cement, 1 cubic foot of sand, and 1 cubic foot of pebbles or broken stone. A 1:2:3 mixture means 1 sack of portland cement, 2 cubic feet of sand, and 3 cubic feet of pebbles or broken stone. In other words, the first figure stands for the volume of cement, the second for the volume of sand, the third for the volume of pebbles or broken stone. A 1:2 mixture indicates a mortar, that is, a mixture consisting of 1 sack of portland cement and 2 cubic feet of sand. In proportioning concrete by volume 1 sack of portland cement is always considered as equal to 1 cubic foot; therefore, if 1-sack batches are being mixed the portland cement need not be measured.)

TABLE OF RECOMMENDED MIXTURES

1:1:1 Mixture for

The wearing course of two-course floors subject to heavy trucking, such as occurs in factories, warehouses, on loading platforms, etc.

1:1:1½ Mixture for

The wearing course of two-course pavements, in which case the pebbles or crushed stone is graded from ¼ to ½ inch.

1:2:3: Mixture for

Reinforced concrete roof slabs.

One-course concrete road, street, and alley pavements.

One-course walks and barnyard pavements.

One-course concrete floors.

Fence posts.

Sills and lintels without mortar surface.

Watering troughs and tanks.

Reinforced concrete columns.

Construction subjected to water pressure, such as reservoirs, swimming pools, storage tanks, cisterns, elevator pits, vats, etc.

1:2:4 Mixture for

Reinforced concrete walls, floors, beams, columns and other concrete members designed in combination with steel reinforcing.

Concrete for the arch ring of arch bridges and culverts; foundations for large engines, causing heavy loading, some impact and vibration.

Concrete work in general subject to vibration.

1:2½:4 Mixture for

Silo walls, grain bins, coal bins, elevators and similar structures.

Building walls above foundation, when stucco finish will not be applied.

Walls of pits or basements, subject to consideable exposure to moisture, but practically no direct water pressure.
Manure pits, dipping vats, hog wallows.
Backing of concrete block.
Base of two-course road, street and alley pavements.

1:2½:5 Mixture for

Walls above ground which are to have stucco finish.
Base of two-course sidewalks, feeding floors, barnyard pavements and two-course plain concrete floors.
Abutments and wing walls of bridges and culverts, dams, small retaining walls.
Basement walls and foundations for ordinary conditions where watertightness is not essential.
Foundations for small engines.

1:3:6 Mixture for

Mass concrete such as large gravity retaining walls, heavy foundations and footings.

1:1½ Mixture for

Inside plastering of water tanks, silos, and bin walls, where required, and for facing walls below ground when necessary to afford additional protection against the entrance of moisture.

1:2 Mixture for

Scratch coat of exterior plaster (cement and stucco).
Facing block and similar concrete products.
Wearing course of two-course walks, floors subjected only to light loads, barnyard pavements, etc.
Ornamental objects where smooth surface, also watertightness, is very necessary.

1:2½ Mixture for

Intermediate and finish stucco coats.
Fence posts when coarse aggregate is not used.

1:3 Mixture for

Concrete block when coarse aggregate is not used.

Concrete brick.

Concrete drain tile and pipe when coarse aggregate is not used.

Ornamental concrete products.

CONVENIENT ESTIMATING TABLES AND EXAMPLES

QUANTITIES OF PORTLAND CEMENT, SAND AND PEBBLES OR CRUSHED STONE FOR 100 SQUARE FEET OF CONCRETE 10 INCHES THICK, EQUAL TO 3.08 CUBIC YARDS

PROPORTIONS			QUANTITIES		
Sacks of Cement	Cu. Ft. of Sand	Cu. Ft. Pebbles or Stone	Sacks of Cement	Cu. Yd. of Sand	Cu. Yd. Pebbles or Stone
1	1		60.2	2.23	
1	1½		47.7	2.65	
1	2		39.4	2.92	
1	2½		33.8	3.13	
1	3		29.5	3.29	
1	1	1	41.7	1.54	1.54
1	1½	3	23.4	1.30	2.60
1	2	3	21.5	1.59	2.38
1	2	4	18.5	1.37	2.74
1	2½	4	17.2	1.59	2.54
1	2½	5	15.4	1.43	2.86
1	3	5	14.2	1.58	2.64

NOTE: These quantities can be safely used for estimating, ordering materials and, after the work is done, as a check to prove that the required quantity of cement has been used. Actual quantity of materials used in the concrete should not vary more than ten per cent above or below the quantities given in the table.

This table can readily be used for any concrete structures which can be measured in area and which are of uniform thickness over any considerable area such as walls, floors, walks, etc.

The following examples illustrate the use of the table:

Example 1.—Required the quantity of materials for a 12-inch thick basement wall, 6 feet 5 inches high above footing, for a house 25 feet by 40 feet outside dimensions. The footing 1 foot 6 inches wide and 6 inches thick. Concrete proportioned 1:3:5.

Wall.—

Length of wall 25+25+39+39=128 ft.

Height of wall 6 ft. 5 in. = $6\frac{5}{12}$ = 6.417 ft.

Area of wall = 128 × 6.417 = 821.4 sq. ft.

Thickness of wall = 12 in.

Quantities of materials for wall concrete:

Factor for multiplying units in

$$\text{table} = \frac{821.4}{100} \times \frac{12}{10} = 8.214 \times 1.2 = 9.8568;$$

Take 9.86

Sacks of cement = 14.2 × 9.86 = 140.0

Cu. yd. of sand = 1.58 × 9.86 = 15.6

Cu. yd. of pebbles or crushed stone = 2.64 × 9.86 = 26.0

Footing.—

Length of footing = 25.5 + 25.5 + 37.5 + 37.5 = 126 ft.

Width of footing = 1 ft. 6 in. = $1\frac{6}{12}$ = 1.5 ft.

Area of footing = 126 × 1.5 = 189 ft.

Thickness of footing = 6 in.

Quantities of materials for footing:

Factor for multiplying units in the

$$\text{table} = \frac{189}{100} \times \frac{6}{10} = 1.89 \times .6 = 1.134 = 1.13$$

Sacks of cement = 14.2 × 1.13 = 16.0

Cu. yd. of sand = 1.58 × 1.13 = 1.8

Cu. yd. of pebbles or stone = 2.64 × 1.13 = 3.0

Total quantities of materials:

Sacks of cement = 140 + 16 = 156.0

Cu. yd. of sand = 15.6 + 1.8 = 17.4 or 17.5

Cu. yd. pebbles = 26.0 + 3 = 29.0

Example 2.—Required the quantities for a concrete floor for a basement. Interior dimensions of the basement 23 feet by 38 feet. Floor 5 inches thick over all, with 4-inch base of concrete proportioned 1 :2½ :5, and 1-inch wearing course composed of cement mortar proportioned 1 :2.

Area of floor $= 23 \times 38 = 874$ sq. ft.

Factor for multiplying quantities in table for

$$\text{base} = \frac{874}{100} \times \frac{4}{10} = 8.74 \times .4 = 3.5$$

Quantities of materials for base concrete:

Sacks of cement $= 15.4 \times 3.5 = 54.0$

Cu. yd. of sand $= 1.43 \times 3.5 = 5.0$

Cu. yd. of pebbles or stone $= 2.86 \times 3.5 = 10.0$

Factor for multiplying quantities in table for

$$\text{wearing surface} = \frac{874}{100} \times \frac{1}{10} = 8.74 \times .1 = .9$$

Quantities of materials for wearing surface mortar:

Sacks of cement $= 39.4 \times .9 = 35.5$

Cu. yd. of sand $= 2.92 \times .9 = 2.6$ cu. yd.

Total quantities of materials for floor:

Sacks of cement $= 54.0 + 35.4 = 89.5$

Cu. yd. of sand $= 5.0 + 2.6 = 7.6$ or 7.5

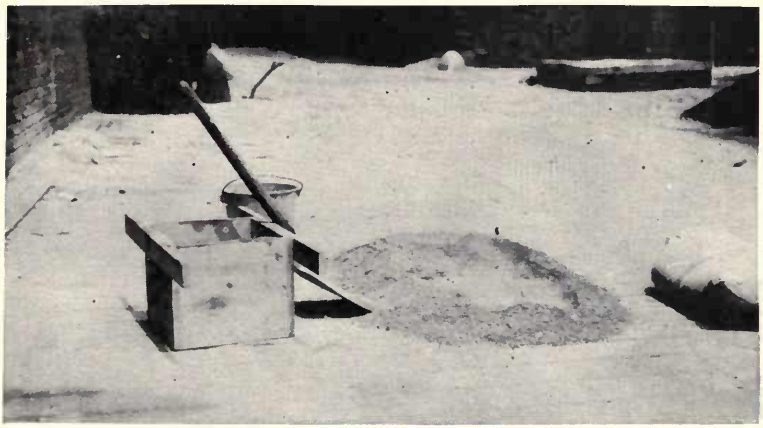
Cu. yd. of pebbles or stone $= 10.0$

MIXING CONCRETE

Hand Mixing.—Where only small quantities of concrete are to be mixed or concrete work is to be done at rather infrequent intervals, it is usually more economical to do the mixing by hand. If any considerable quantity of concrete is to be mixed or the job is a large one, a batch machine mixer will be found more economical, will do away with the labor of hand mixing, and will insure greater uniformity of mixing.

Where concrete is to be hand mixed, a watertight mixing platform such as described elsewhere under the heading "Tools and Equipment," should be used. Hand mixing can be done on a smooth wood or concrete floor, but concrete never should be mixed on the ground, because soil will unavoidably be shoveled into the concrete and will reduce its strength if not spoil it entirely.

Size of Batches.—It is always best if possible to mix quantities or batches of concrete that will require the use of 1 sack of cement, because a sack of cement (94 lb. net) is considered as 1 cubic foot in proportioning concrete by volume, so the cement need not be measured. If, however, the work calls



Sand and cement mixed ready to receive the water. A measuring box also is shown.

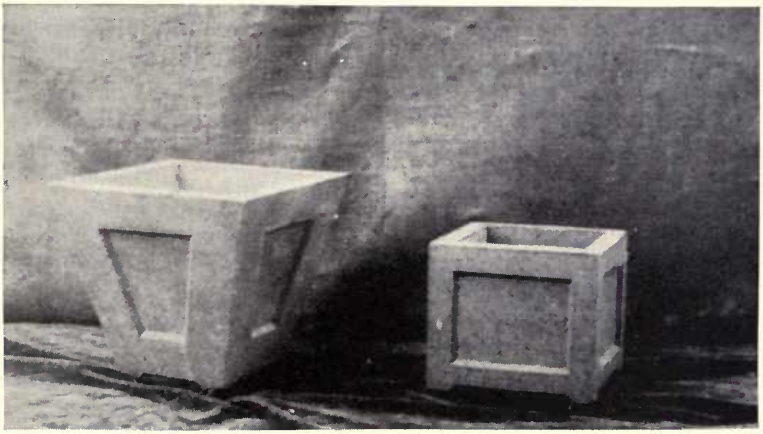
for smaller quantities, then it will be necessary to weigh out cement equal to ¼, ½ or some other fractional part of a sack because when dumping it from the sack its fluffiness will deceive one as to its bulk.

Correspondingly small volumes of sand and pebbles must also be measured. Cement sacks should be carefully taken care of and not allowed to get wet, as they will be bought back by the dealer, if in good condition.

Order of Mixing.—In hand mixing, the required amount of sand should be measured first in the measuring box and spread out in a layer of uniform thickness on the mixing board. There should then be dumped on this sand the measured or weighed quantity of cement for the size of batch being mixed. Sand and cement should then be turned thoroughly a number of times, square pointed shovels being used for the purpose, until the two materials have been so thoroughly mixed that the mass is of uniform color throughout, free from streaks of gray or brown, indicating that the cement and sand have been thoroughly combined. This will usually require that the materials be thoroughly turned three or more times.

School boys mixing concrete preparatory to laying concrete sidewalk.

Next the required amount of pebbles or broken stone should be measured, thoroughly sprinkled, and added to the sand-cement mixture. One or two turnings should be given the materials while dry, after which water should be added, preferably from a watering pot with sprinkler attachment, or from hose with spray nozzle, water being added gently while some one turns the materials repeatedly to prevent the water from washing away the cement. The combined materials should be turned several times until every pebble or particle



Two simple concrete flower or fern vases. The simplest ornament is here introduced—depressed panels.

of broken stone is thoroughly covered with a sand-cement mortar and the whole mixture is of the required consistency. One should be very careful not to use too much water. Sometimes when it seems a little more water is necessary, it will be found that slightly more mixing will prove that the consistency is just right.

Amount of Water.—For most classes of concrete work the amount of water required is that which will produce a mixture that when shoveled into a pile will gradually tend to spread

of its own weight; at least, it will do so just as soon as disturbed. This is usually called a "jelly" or "quaky-like" consistency. If any more water than required to produce such a consistency is used, the concrete will tend to flow, and except in very few instances, such a mixture is too wet for best results. An exception is when the concrete is to be used in making some object where the space between inner and outer forms is very narrow, then it might be necessary to use a little wetter mixture to make the concrete settle to all parts of the mold or form. Never must enough water be used so that when handling the mixture on a shovel the pebbles or broken stone will separate from the sand-cement mortar. It is not possible to state exactly what quantity of water shall be used for any volume of dry materials owing to the variation in such materials themselves; the sand may be quite dry—at other times it may contain a considerable quantity of moisture. In the first case, more water would be required to make a mixture of the consistency described than in the latter case. Again, when certain kinds of crushed stone are used in place of pebbles, they may absorb more water than other kinds of stone, thus making it necessary to vary the quantity of water required as compared with some other mixture to produce the right consistency.

Machine Mixing.—If concrete is to be mixed by machine, a mixer of the batch type is preferable because the several ingredients for every batch of concrete must be separately measured. This insures correct proportions. There are mixers of what are known as the continuous type. These receive the several ingredients of concrete—cement, sand, pebbles or broken stone—from hoppers. Frequently, however, a clogging of the hopper spout due to dampness of the sand or packing of the cement or some other defect of operation will prevent desired proportions being secured, hence the concrete will not be uniform.

Size of Machine Batches.—Batches should not be larger

than suited to the capacity of the mixer drum, nor larger than can be placed within thirty minutes after mixing. Care should be taken not to place more materials in the drum than recommended by the manufacturer. There must be enough unoccupied space in the mixer drum so that the concreting materials can tumble about freely while the mixer drum is being revolved, thus making it possible to thoroughly mix the concrete. As a rule, the materials for a batch of concrete should not occupy a volume in the mixer drum exceeding one-third of its entire volume when mixed.

Speed and Time of Mixing.—The mixer drum must not be revolved too rapidly for that will cause the materials to cling to the inner surface of the drum rather than be tumbled about and thoroughly mixed. Mixing should continue for not less than 1½ minutes after all materials have been placed in the drum.

Some Important Details.—In mixing concrete the sand and cement should never be combined very far in advance of adding the required quantity of pebbles or broken stone because moisture in the sand will cause the cement to commence hardening and this will affect the strength of the concrete. The action which takes place when cement and water are combined is what causes the hardening of concrete. This action commences very shortly after the water has been added to the other materials. Therefore when any concrete work is planned forms should be ready so that concrete can at once be placed and all the hardening action take place in the form or mold.

Placing Concrete.—There are variations in the manner of placing concrete due principally to the nature of the work or the conditions under which it must be carried on. Sometimes in laying the foundation for a building, the earth walls of the trench are firm and no forms are necessary for that portion of the wall below ground level. In such a case, concrete, as soon as mixed, is shoveled into the open trench and

compacted either by tamping or spading to its utmost density. Tamping is done only when mixtures containing less water than the quaky or jelly-like consistency are used but even in a mixture containing less water than a quaky one, there should still be enough water so that when the concrete is tamped, a film of water will flush to the surface under vigorous ramming. Care should be taken when dumping concrete into a trench unprotected by forms, not to knock down earth from the side walls of the trench, thus permitting earth to become mixed with the concrete. Planks should be laid alongside and across the trench for convenience of the workers. This will prevent them from causing cave-ins of the trench walls. Concrete work should always be planned so that the quantity of concrete that will be placed during whatever time is to be devoted to the work, can be closely estimated so that when work is temporarily stopped its condition will be such as to make resuming the work easy.

In placing concrete for a foundation or building wall, layers no thicker than 6 or 8 inches should be placed at one time. This will permit thorough tamping or spading to make the concrete bond with or adhere to that previously placed.

Tamping or Spading Concrete.—Quaky concrete, instead of being tamped, is spaded thoroughly between form faces and next to form faces so as to secure the greatest possible density and to release air bubbles that may be in the mixture. Narrow or pointed spading tools are sometimes needed to thoroughly work the concrete around reinforcing metal, such as wire mesh fabric or steel rods, also when placing the concrete in a very thin section, such as the sides of a flower box or vase. In such cases small chisel-pointed sticks or rods will serve as spading tools and only a little concrete should be placed at a time so that it can be thoroughly spaded. Work on such small objects especially should be continuous from start to finish, otherwise there will be a seam disclosed in the work when the form or mold is removed and leakage will

take place through such a seam, not to mention the fact that the object will be weakened.

Using an iron rod to compact the concrete in the mold for a flower box being cast bottom side up. Working the rod up and down also helps to secure a smooth surface finish.

Jarring the mold to help release air that might be trapped in the concrete and also to cause the mixture to settle thoroughly to all parts of the form.

It is sometimes necessary to carry the concrete some distance from the mixing platform as the work progresses, or to frequently move the mixing platform to prevent unnecessary handling or transporting of concrete.

Boarding Up Forms.—Walls for small buildings, such as garages, milkhouses and many small farm buildings are usually not more than 6 inches thick. One set of forms is usually set up complete before work is started. This may be either outer or inner form, but the other one should not be completely boarded up before concreting has commenced because if both forms are boarded up to a height of 8 or 10 feet, it will be impossible to place concrete in this narrow deep space and spade it or otherwise compact it so that a regular, smooth surface finish is secured. Another objection to placing concrete in deep forms is in dumping the mixtures through such a height, pebbles or broken stone are likely to separate from the sand-cement mortar and this will cause varying density in the concrete because of pebble pockets due to separation of materials. One form should be boarded up only as concrete is placed, say, 2 feet at a time. This will permit the concrete to be thoroughly spaded, which will make certain of a better surface.

Protecting the Finished Work.—Proper protection of concrete work after the actual concreting has been finished is of utmost importance. As already mentioned, the action that causes concrete to harden is brought about by the chemical combination of cement and water, and this hardening action, although commencing very soon after concrete is mixed, is not complete for a considerable length of time. Complete hardening requires a length of time that varies. It is dependent upon the amount of water used in the mixtures and the season of the year, that is, whether summer or winter. Concrete hardens slowly in cold weather. It hardens rapidly in warm weather if other conditions are favorable, and this

means protecting it so that the water which was used in the mixture will not be lost by evaporation or otherwise.

In some classes of work, especially where the mass is considerable, leaving forms in place for a few days affords all the protection necessary. If, however, forms are removed and the weather is hot and dry, the work should be sprinkled several times daily to prevent loss of water by evaporation and also to make the concrete harden more uniformly.

If a concrete flower box is being made, it will, under favorable conditions, be possible to remove the forms within from 12 to 24 hours after the last concrete was placed. At this time such imperfections as may appear on the surface are carefully patched up with sand-cement mortar, then the box should be carefully immersed in a tank so that the concrete will everywhere be covered with water. Left to harden in this manner the concrete will acquire more uniform strength within a given time than can be secured by any other equally simple means.

Protecting Walks and Floors.—Concrete walks and floors may be protected by covering them with a layer of moist earth or sand, hay, straw or similar material just as soon as it is possible to apply such a covering without marring the surface. This covering should be left in place for several days, depending upon the season of the year and the rapidity with which the concrete hardens under the prevailing temperature conditions. Also, the covering should be kept wet by frequent sprinklings daily during the time it is left in place. Usually concrete walks should not be used until they are at least a week or ten days old.

Walls and exposed vertical concrete faces should be protected from hot sun and drying wind. They can be kept wet by sprinkling. It may be necessary to hang old canvas or burlap so as to protect the surface from the sun's rays.

Concrete work may have been performed with proper observance of all requirements up to the point of protecting

the finished work, yet if this is neglected a great part of the success that would have come from observing other requirements will be lost. It is especially necessary to protect new concrete watering tanks, troughs and other receptacles that are to hold liquids, because too rapid drying out of the concrete will often prevent it from being watertight.

Concrete Work Done in Cold Weather.—One other condition of protecting concrete work should be referred to—that is, protecting such work when it is done during cold weather. Many persons are not aware that successful concrete work can be done when temperatures are low. All that is necessary when working under such conditions is to observe a few simple precautions. These consist principally of heating the sand and pebbles or broken stone and mixing water so that when the concrete mixture has been made, it will have a temperature of at least 80 degrees, then quickly placing this mixture in the forms so that none of the heat will be lost and covering or otherwise protecting the work so that this heat will be retained in the concrete until early hardening has been completed. Usually this can be arranged for by observing a few simple measures.

Briefly, the essentials of success in concrete work done in cold weather are the following:

Sand and pebbles or broken stone must be free from frost or lumps of frozen materials, otherwise they must be thawed out before being used in a concrete mixture. As cement forms but a relatively small bulk of the materials in any batch of concrete, it need not be heated. Mixing water should always be heated.

Although adding common salt to mixing water will prevent freezing of concrete that has not hardened, provided the temperature does not go too low, salt simply lowers the freezing point of the mixing water. It does not supply what is most needed—heat and warmth. It delays instead of hastens the

hardening of the concrete. If too much salt is used, it will affect the final strength of the concrete.

Sand and pebbles or broken stone and mixing water should be heated so that the concrete when placed has a temperature of from 75 to 80 degrees.

Some sands are injured by too much heat. The same applies to certain kinds of pebbles and broken stone. Usually if they are heated to 150 degrees, this will be high enough and the materials will not be injured.

Place concrete immediately after mixing, so that none of the heat will be lost before placing in the forms.

Warm metal forms and reinforcing before placing concrete. See that forms are free from ice and snow. Forms can be warmed by turning a jet of steam against them or by wetting with hot water.

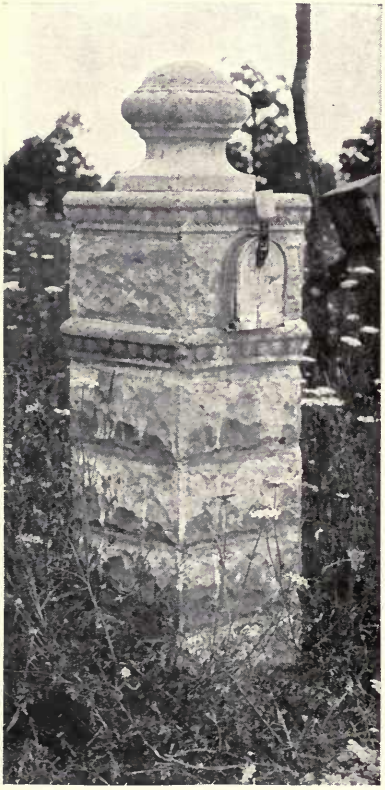
Protect the concrete immediately after placed. Canvas covering, sheathing, housing in the work, or hay or straw covering, will furnish the required protection for some kinds of concrete work. In addition, small oil or coke-burning stoves may be used in enclosed structures to keep up the interior temperature.

Temperatures that are not low enough to freeze concrete may nevertheless delay its hardening for a considerable time. Do not expect concrete placed when the temperature is low and remains low for some time afterward, to be safe for use as soon as though the work had been done during warm weather. Cover and protect any section of the work as soon as completed. In severe cold weather, keep it protected for at least five days.

Forms must not be removed from concrete work too early. This applies to work done at any season but is particularly important with work done during cold weather.

Concrete that has frozen sometimes closely resembles concrete that has thoroughly hardened. If struck with a hammer it will often ring like properly hardened concrete. Before

removing forms, examine the work carefully to see whether it has hardened or simply frozen. Pour hot water on a spot or turn the flame of a torch, or direct a jet of steam against the concrete. If frozen the heat will soften the concrete by thawing the water contained in it.

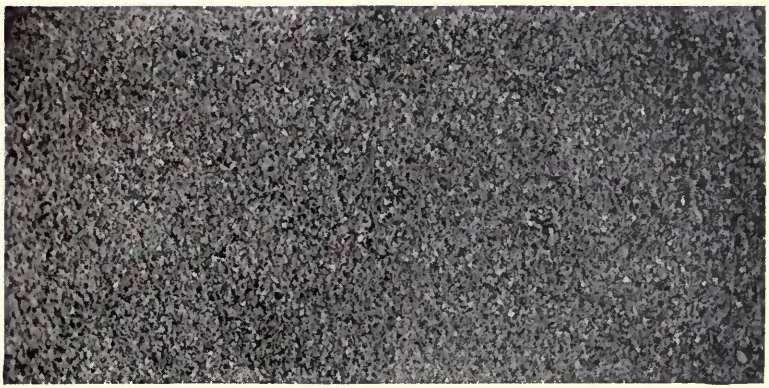


Column of concrete block made to serve as a container for the rural delivery mail box. This idea could be made a feature of concrete gate posts.

SURFACE FINISH OF CONCRETE

Variety of Finishes Possible.—One of the many advantages which concrete possesses is that by various kinds of manipulation a great variety of surface finish can be secured. Some of these finishes are given entirely after the work has been completed, while others are partly arranged for when the materials are being selected.

In small ornamental objects, colored sands and selected aggregates, such as marble chips, granite screenings, etc., are often used in place of the ordinary aggregates. After forms

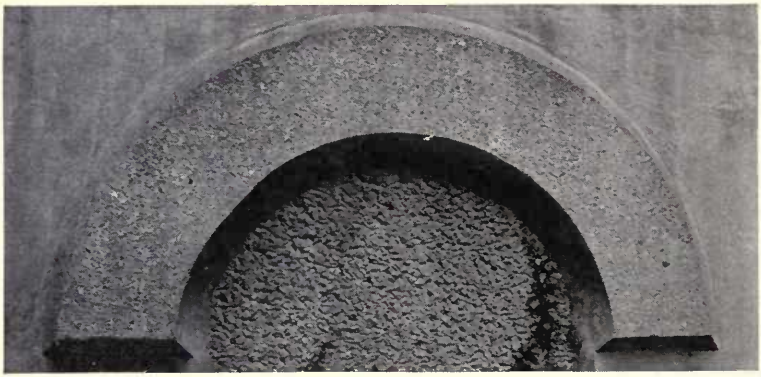


An example of rubbed finish showing a surface in which fine aggregate was used in the concrete surfacing mixture.

have been removed, the surface is treated in some one of a number of different ways to take advantage of color effects that can be secured by using such selected materials.

Leaving Surface as Produced by Forms.—The simplest form of surface finish that can be given to concrete is that secured by properly placing the material in well-made forms and spading the concrete next to form faces so that coarse particles will not be exposed on the surface. Such a surface finish, however, is rather monotonous. The only color it has

is due almost entirely to the cement. The sand does not affect the color of the surface to any great extent because the surface of the sand particles is covered with a film of cement. If forms have been well made, the only treatment that is necessary to give such a surface is to patch up small spots or imperfections due to not having everywhere thoroughly forced back the coarse aggregate from the form face. These imperfections should be filled with a mortar of the same proportions of cement and sand as the mortar of the concrete,



A combination of the rubbed and tooled surfaces. This is a little piece of concrete bridge ornamentation.

and rubbed smooth and even with the general surface of the object by using a wood float. If the whole surface of the object is gone over in this manner, a fairly good finish can be secured at little expense. The surface will be as smooth as the forms against which the concrete is placed, and if the concrete was properly proportioned, the surface will also be dense and watertight. Dressed lumber will produce a smooth surface finish if forms are tightly jointed so that the sand-cement mortar cannot flow into joints, thus molding ridges or seams on the surface. If surface finish is to depend on forms

alone, then metal or metal-lined forms will give the best surface.

Cement-Water Wash.—Another method of finishing a concrete surface consists of painting the concrete with a cement wash, usually consisting of 1 part cement and 1 part fine sand, mixed with water to form a paint. This is applied with a brush after forms are removed. It fills up the pores and covers small inequalities and grain marks of wood forms and gives a smooth surface of even finish and uniform color. However, it is likely to check and hair crack and sometimes scales off in spots, if not entirely. For this reason it is not a reliable surface finish.

"Floating" With Stone or Wood Float.—There are several other methods of after treatment which in general are as follows: Forms are removed as soon as the concrete has hardened sufficiently to be self-sustaining, or to permit handling the object if reasonable care is used. Ridges caused by joints in forms are carefully chipped off, the concrete surface is thoroughly wet, and rubbed with a carborundum block, the surface being kept wet constantly while so rubbed. Another method of rubbing the surface is to use a wood float or trowel. The surface must be kept well flushed with water during the rubbing and thoroughly washed after rubbing has been completed. The earlier the surface is rubbed after form removal, the better will be the results. In other words, the concrete should be rather "green" (not hard). Rubbing removes most of the inequalities, fills the pores and small cavities and gives to the surface a uniform finish and appearance. Such treatment is proof against the pitting and scaling that frequently result from painting on a cement and water paint, or grout, as it is called.

Selected Aggregates.—By far the most attractive surface finishes that can be given to concrete are those which are in large part prearranged when mixing the concrete. That is, selected aggregates are used instead of common sand, these

materials being chosen principally because of their color. For example, instead of using ordinary sand, white sand and marble chips, or granite screenings, crushed feldspar, mica and micaspar, crushed slag, garnet sand and similar colored rock materials are used as aggregates.

Mixtures are prepared and placed in the usual way. When the concrete has hardened so that forms may safely be removed, the surface of the object to be treated is gone over in one of several ways to produce the desired effect.

How Surface Finish Is Secured.—With selected aggregates, the surface finish is obtained by washing off the film of cement that coats the particles, thus exposing their surfaces in the surface of the concrete and in that way revealing their color. If the forms are removed within 24 hours after placing the concrete in the mold, it is usually possible to wash off the surface film of cement by merely scrubbing the surface of the object with a stiff bristle brush kept wet with water. If, however, the concrete has become too hard to permit exposing the aggregate surfaces in this manner, then an acid wash is used. This consists usually of 1 part of hydrochloric (commercial muriatic) acid in 3 or 4 parts of water. This wash is applied with brush to the surface and light scrubbing given until the surface film of cement is loosened from the aggregate particles. When this has been done, the surface of the object must be washed immediately and thoroughly with clean water containing no acid so that all trace of acid is removed and its further action prevented. If this were not done, the acid would continue to act on the cement and thus loosen some of the aggregate particles.

Facing Mixtures.—Sometimes economy results from using two classes of mixtures for a concrete object that is of considerable volume. That is, if a surface finish by means of colored aggregate is the desired end, then a concrete mixture containing such aggregate is used only for the face of the object and back of this facing mixture an ordinary concrete

mixture in which common sand and pebbles or broken stone are the aggregates. When using facing mixtures in this manner, it is necessary that the facing mixture be banked or plastered up the sides and faces of the mold a little in advance of the mixture that is used for the center or backing. It is also necessary that the two mixtures be of the same consistency so that when compacting the concrete in the mold the two mixtures will thoroughly unite.

Combining Several Colored Aggregates.—Variations in color and texture of a surface which are to be secured by wash-

An example of surface finish in the depressed panels, secured by tooling the surface with a bush hammer.

ing or otherwise exposing the aggregate can be made almost without number by combining two or more selected aggregates. For instance, a mixture of yellow and of white marble chips, or a mixture of gray granite screenings and black crushed slag with a little micaspar or mica, are examples of possible variations. Such mixtures produce a beautiful surface texture when the film of cement is removed by scrubbing,

either with water or the acid solution, depending upon the age of the concrete. Often white portland cement is used, and in such cases micaspar, white marble or mixed light-colored aggregates.

Tooled Surfaces.—Another method of finishing the concrete surface is to tool it in several ways similar to the methods of cutting or tooling stone. But in preparing for such a surface finish it is necessary to pay particular attention to selecting the aggregate and still greater attention to proportioning the concrete mixtures so that it will be certain there is sufficient cement used to fill all voids or air spaces in the bulk of aggregates, thus firmly bonding all particles into one solid mass. If mixtures are lean, that is, contain too little cement, there will not be enough bonding or binding material in the mass to prevent the small particles of aggregate from being dislodged or broken out when tooling the surface.

When a concrete surface is to be tooled, it is necessary that the concrete be allowed to harden for a greater length of time than for the washing methods. The concrete must have an almost flint-like hardness so that aggregate particles will not be broken out of the surface. It is the particles themselves that must be tooled to give the desired effect. Usually a month of hardening under proper conditions of protection will be sufficient. Objects that have been steam hardened first are even better for tooled finishes.

Although the concrete surface may be tooled by using chisels just as marble and other stones are carved, the usual tooling consists of hammering with a bush or "pean" hammer, such as is used by stone dressers. When this is used properly the aggregates are slightly cut, thus disclosing their color and giving to the concrete surface an appearance like that of cut stone. Best results, when bush hammering is to be used, come from selecting an aggregate of uniform texture and hardness. Broken stone instead of pebble aggregates are then best, since most natural pebbles vary greatly in hard-

ness and the bush hammered pebble surface has not nearly so uniform an appearance as the bush hammered surface in which stone aggregates of uniform hardness were used.

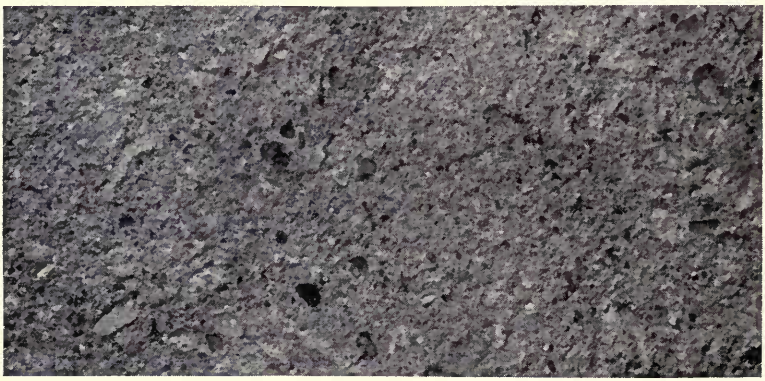
Polished Surfaces.—Concrete surfaces may be given a polish similar to that obtained on granites and marbles. The degree of polish that may be secured depends, however, upon the aggregate used and the thorough grading of it so that the least possible amount of cement necessary to bond the particles will be required. Examples of such finish may be seen in so-called mosaic or terrazzo floors. Such a surface to receive the best polish must expose as great a surface of aggregate as possible—the nearest approach to 85 per cent that can be attained.

Using Color Pigments.—Another variation possible in concrete surfaces is secured by adding coloring matter to the cement. This practice also can be combined with that of selecting the aggregates. For example, if a uniform reddish tone is desired for surface finish, then coloring matter such as red oxide of iron may be added to the cement and pink or red granite chips used as aggregate. Such a concrete is then treated by washing and scrubbing or rubbing the surface with carborundum stone.

Coloring by Immersion.—Still another way of varying the color of concrete surfaces is by immersing the finished object in some solution that will dye or stain it.

"The importance of thoroughly mixing colored pigment with the cement before adding the aggregates should be appreciated by anyone attempting to make concrete in colors. If the object being made must possess a certain maximum of strength, it should not be placed in the coloring bath until the concrete has thoroughly hardened, as filling the pores with the coloring matter in solution stops the chemical action or changes taking place in the cement leading to hardening of the concrete.

"Coloring by absorption is effective on surfaces of concrete after it comes out of the mold or after being treated with acid or tools. Surfaces that have been colored by absorbing mineral or metallic colors are less absorbent and the action of the weather on the metallic colors is the same as on real metals, increasing the beauty of coloring by the usual oxidization noticed on bronze and copper. Surfaces of concrete treated by such methods become so hard and dense that they will take a uniformly dull or high gloss polish. Flower pots, vases, flower boxes and similar wares finished



Another example of tooled surface finish.

by this method are very attractive, the artistic possibilities of such treatment being limited only by the colored sands and taste employed by the worker. Aniline colors and the sulphates of copper and iron are considered best adapted to the making of solutions in which to color concrete by this capillary method."*

In aiming at color effects secured in part by mixing colors with the cement used to make a batch of concrete, it is very essential—if permanent tints are to be secured—that only

*From "Concrete," published in Detroit.

reliable pigments be used. The cement, sand and coloring matter are mixed together dry, and it is advisable to experiment a little to find how much color is needed to give the desired shade. When water is added to the mixture, the mortar will appear considerably darker than the final surface will be when thoroughly hardened. By mixing 5 pounds of coloring matter with a sack of cement, the following colors are obtained:

Raw iron oxide will give a bright red;
Roasted iron oxide will give brown;
Ultramarine will give bright blue;
Yellow ochre will give buff to yellow;
Carbon black or lampblack will give a gray to dark slate;
A mixture of equal parts of carbon black and red iron ore gives dull reds.

In all cases the addition of mineral colors causes some loss of strength but this is not of great importance on ornamental work. In general, only mineral colors are to be recommended as regards permanence of effect produced. Blues and greens are not reliable and will fade in course of time.

Sand Blast Finish.—Another method of finishing a concrete surface that is used sometimes may be mentioned, although its application is not within the average concrete worker's range. That is the sand blast. No doubt many readers have seen a sand blast machine being used to clean the exterior of some large building. By this method a stream of fine sand is expelled from a jet or nozzle under high pressure created by compressed air, and the small particles striking the surface wear from it a thin film, thus exposing its true color and texture.

Imitating Coursed Stone.—In laying up concrete walls the effect of stone courses can be produced by placing V-shaped strips or battens properly arranged horizontally and vertically on the inside face of the forms. Vertical battens should be

limited to construction joints rather than used to imitate stone work. The marks or scorings thus produced have somewhat the effect of paneling on the surface, that is, they break the flat monotonous appearance of large surfaces. But while it is perfectly legitimate in concrete work to secure surface finish in the various ways described, it is not desirable to attempt treatments that produce gross imitations of some other material. As an example of such an attempt, the old type of concrete block may be mentioned. Here a broken rock-faced appearance was attempted by the use of different types of face plates in the molds in which the block were formed. It is hard to imagine a more monotonous and, in time, more displeasing surface finish than the imitation stone one obtained in that manner.

Stucco.—Nearly everyone has seen houses or other buildings finished by plastering with a cement mortar. This finish is called "stucco."

Stucco is a mixture of portland cement, sand and water, with which there is usually combined a small quantity of hydrated lime, so that the plaster or mortar will work more readily under the trowel. The materials should be proportioned 1 sack of portland cement, 2 cubic feet of sand, and a quantity of hydrated lime equal to one-tenth of the cement. The hydrated lime should first be thoroughly mixed with the cement while the two are dry, then clean sand should be added and the whole mass mixed by turning with shovels several times until of uniform color. Water is added until the required consistency is obtained. If hydrated lime cannot be conveniently obtained, it is necessary to use slaked lime. Hydrated lime is merely a commercial name for lime that has been thoroughly slaked by mechanical means.

Only a small quantity of stucco plaster should be prepared at a time as the cement sets rapidly and if this occurs before the plaster or mortar is applied, the results will not be satisfactory. The stucco mixture should be wet enough to work

easily under the trowel but stiff enough to prevent any flowing after applied to the metal lath, expanded metal, or whatever surface is being covered.

In building construction usually two or more coats of stucco are applied. Sometimes a third coat is used for the purpose of securing the required final finish. Before applying a second or third coat the one last placed must be scored or marked on the surface while soft, with some kind of a scratch tool, so that there will be a good bond or key for the next coat. A tool suitable for scratching the surface can be made from a short piece of ½-inch thick board, notched sawtooth fashion on one end and shaved down on the other to form a

A method of securing variety in finish of concrete tile. To the left is shown the plain concrete tile before surface treatment. The next illustration shows a paper mask or stencil laid on the wetted concrete surface. Against this there is then thrown a colored concrete mixture in which selected aggregates are used. The third figure shows this in part and also shows the paper stencil being removed so as to give the finished appearance shown in the view to the right.

handle so that the tool will somewhat resemble a small paddle.

Quite a variety of finishes can be given to the final coat. The simplest one is a smooth finish secured by troweling. It is not well, however, to trowel the surface too much, especially with a steel trowel, as the plaster is likely to crack.

Rough Cast Finish.—A rough cast finish can be obtained by using trowels covered with carpet or burlap. To obtain the best results a slight excess of sand is used and the plaster mixed so as not to be too wet.

Slap-dash Finish.—Slap-dash finish can be secured by throwing on the final coat with a wood paddle. This requires some little practice, but after the knack is acquired a very attractive surface can be produced in this manner.

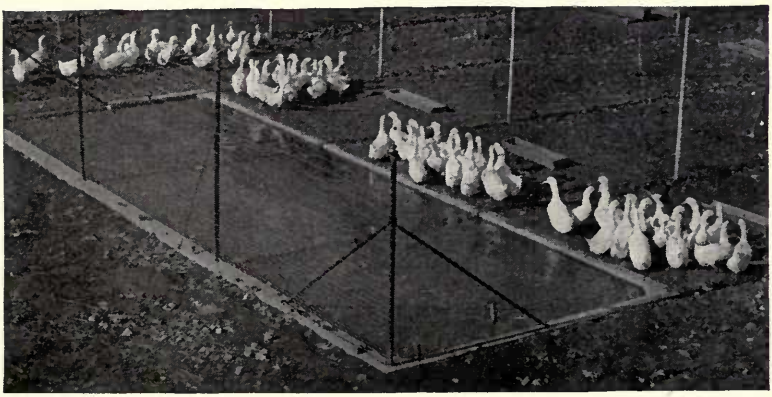
Pebble-dash Finish.—A pebble-dash finish may be obtained by throwing clean pebbles into the fresh stucco of the final coat before it has commenced to harden. Pebbles should be uniformly about ½ inch in greatest dimension, round, and of good color. They should be washed thoroughly clean and be wet when thrown against the mortar. If the color of the pebbles is not to be exposed, then they may be wet with a cement and water paint immediately before thrown against the surface. They are then more certain to adhere firmly to the stucco.

Stucco should not be allowed to dry out rapidly after applied. If the surface is one where it will be exposed to the sun, then some kind of covering must be hung over it or it must be kept wet down by frequent sprinkling during the first few days. Protection must also be given against freezing, for at least 48 hours.

The quantity of cement required to cover a given area with stucco finish depends largely upon the total thickness of the coat to be applied, but assuming three coats, each ½ inch thick and that the mixture is proportioned as previously recommended, a batch of stucco in which 1 sack of cement is used will cover about 17 square feet.

Patching Imperfections.—Sometimes it is necessary to do considerable patching on a concrete surface just because proper care was not taken when placing the concrete. If the object is small it is far more satisfactory to do the work over than to attempt patching it up, but where a considerable volume of materials has been used and remaking the object would be unnecessarily expensive, a certain amount of satisfactory patching may be done if proper methods are used. In all cases the surface to be repaired or patched must first be

thoroughly cleaned of all loose material and the clean sand and broken aggregate surfaces exposed to receive the patching material. After cleaning, the surface to be repaired must be saturated with water so thoroughly that the old concrete will not absorb water from the new mortar or concrete to be used in the patch. Care should be taken not to have thin edges on patches. To avoid this it may be necessary to cut out sound concrete around the place to be patched so as to give deep edges to the patch. If possible, the edges should be slightly undercut. In order that the patch, when finally hardened, will have the same color as that of the surface to which applied, the patching mixture should be of the same proportions as the concrete used in the object being prepared. For instance, if the concrete object was cast of a 1:2:4 concrete, then a 1:2:4 concrete should be used for patching, or a 1:2 cement-sand mortar. In this way the surface of the patch will have the same color as the surface in which it was placed. When hardened, the repair can be hidden quite effectually by carefully rubbing the surface with carborundum stone and water, as described elsewhere.



A concrete swimming pool for the ducks.

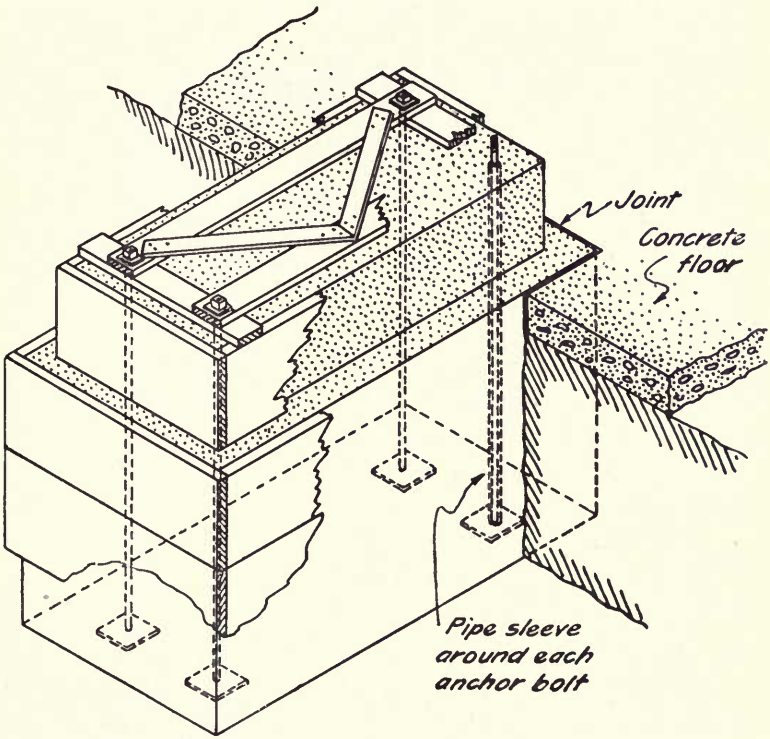
FOUNDATIONS

Suitability of Concrete.—No other material can be used so easily nor to so great advantage for foundations as concrete. Often concrete foundations may be built without using forms, that is, the ground is sometimes firm enough so that if the foundation trench is carefully dug it will serve as the form. Care should be taken when placing concrete in a trench without forms not to knock down earth from the sides so that it would be mixed with the concrete. Of course the only cases where the trench can be made to serve as a form are those where the building which the foundation is to carry is not to have a cellar underneath. In other cases if the ground is firm only an inside form will be needed.

If the foundation is to enclose a cellar or basement, the concrete must be carefully proportioned, mixed and placed and of the right consistency so that the wall will be watertight. Such an end is easy to secure if the principles of concrete practice given elsewhere in this book are carefully followed. Concrete mixtures suitable for various classes of foundation work are suggested in the table of recommended mixtures commencing on page 44.

Foundation for Gas Engine.—A common example of the use of concrete for a building foundation is illustrated on the next page where suggested form and some other details for a small foundation for a gas engine are shown. The method of setting the bolts by which the engine is attached to the foundation is shown in the sketch. A template should be made of straight-grained 1-inch strips with holes bored in them slightly larger than the engine bolts and so located in this template that they are in exactly the same position as the holes in the base of the engine or other machine that is to be set. Before placing concrete the bolts are suspended from the template, heads downward, with nuts above the template and threaded ends projecting a distance not less than the thickness of the engine or machinery base. Ends of bolts

should be covered so that the threads will not be filled up with concrete. Sometimes bolts are set in pipe sleeves, which allows some final adjustment when setting the engine if the template has not been accurately made. Afterward the pipe sleeves are filled with a thin cement mortar or grout.

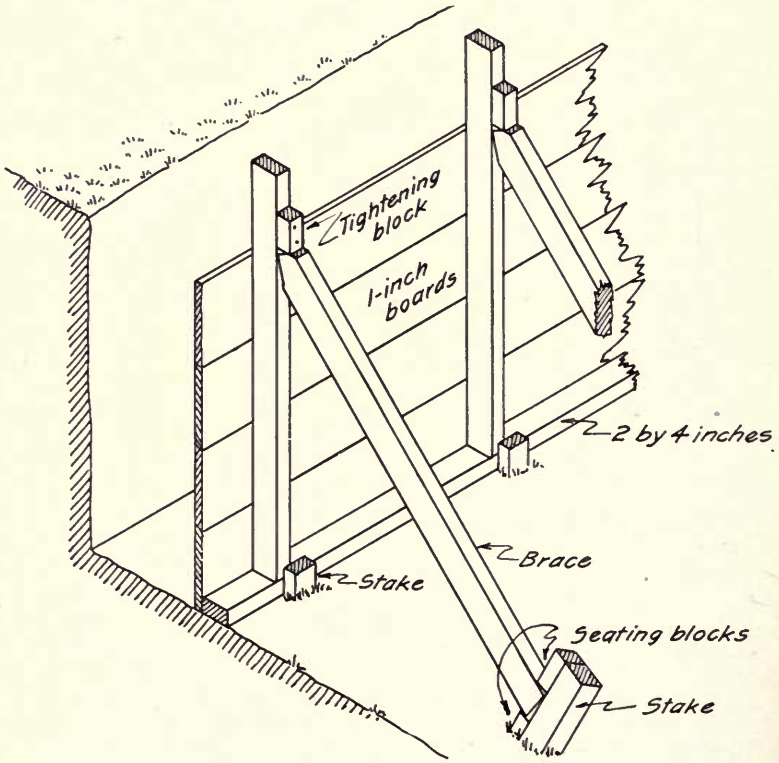


Forms and other details for a foundation such as would be used for a small gas engine.

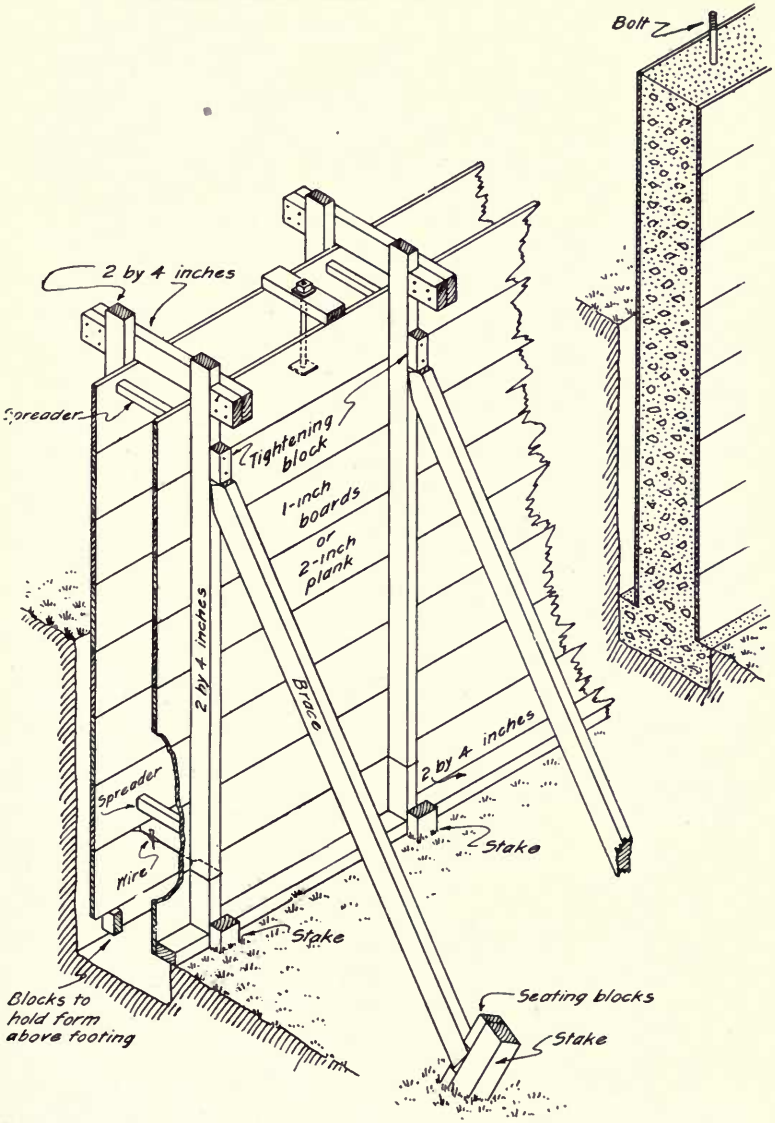
Footings.—All foundations should be planned with proper regard for the weight of the building or structure which they are to support. If the soil is not of the firmest or if the excavation cannot be carried down deep enough to reach firm bearing soil, then it is necessary to start the foundation with

what is called a footing. This is a course of concrete which may vary from 10 to more inches wide and from 6 inches upward in thickness so as to distribute the load of the building over a greater area of ground. After concrete for the footing has been placed, forms are set up a distance apart corresponding to the thickness of the foundation wall, and concreting continued.

Watertight Foundations.—Where watertight construction is important, one other precaution in addition to correct methods of proportioning, mixing and placing of concrete must be observed. That is, care must be taken to secure

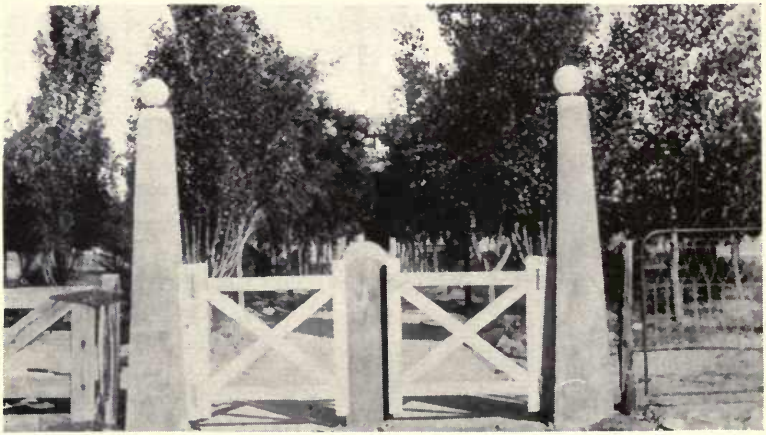


Simple form for concrete foundation wall where only an inside form is necessary.



Forms for a foundation wall where both inside and outside forms are necessary. This form is set up from the bottom of the excavation so as to allow for the placing of concrete to form a footing for the wall.

perfect union or bond between different batches of concrete or between the portions of the work representing concreting done on two different days. If this is not done there will be leakage through a seam or joint otherwise formed. If it is necessary to stop work at any time, concrete should be slightly roughened in the forms by scratching with a stick, then when concreting is resumed this surface should be brushed, washed clean, and painted with a paint of cement and water mixed to about the consistency of cream. New concrete should be placed before this paint has commenced to harden. If the above work is properly done there will be no leakage.



Concrete gate posts with electric light fixture at the top. This work was all done by school boys.

WALLS

Types of Walls.—Concrete walls may be solid (monolithic) or hollow. Hollow walls are secured in either of two ways—by building two solid walls separated by an air space, or by using a type of block which when laid results in a continuous air space in the wall. Block of various types can be used to build a concrete wall that is partly hollow, that is, has air spaces in it, because of cells formed in the block when they are made. A solid wall (monolithic) is naturally much stronger than a block wall, provided both have been built according to the best practice applying to each. A solid wall is one piece, while a block wall is composed of small pieces or units laid up like any other masonry. However, for most small buildings there is little choice between the well made monolithic and well laid block wall.

Dampness on Interior Face of Walls.—The success of concrete walls depends, like any other concrete work, on following certain good concrete practice. Some persons who have built buildings with concrete walls have complained that the interior wall surface was damp. Usually they think this dampness is due to leakage through the wall. Rarely, however, does the wall leak, but owing to the differences in temperature inside and outside the building and the moist vapor in the interior air, water from the air condenses on the wall inside, makes the surface wet, and misleads some persons into thinking that the wall leaks. In climates where there is great extreme of temperature, as between summer and winter, plastering should never be done on the inside of any concrete or masonry wall. Furring strips should be attached to the wall, these strips lathed, and plastering applied to the lath so that there will be an air space between plaster and wall, thus preventing this condensation. The air space acts as insulation.

Reinforcing Walls.—As a rule, foundations do not require reinforcing but most building walls require some reinforcing.

If reinforcing is not placed at the corners of window and door openings and over such openings, cracks may form there due to changes of temperature because of expansion and contraction in the concrete. The same applies at corners of buildings where suitable reinforcing must be embedded in the concrete to "tie in" the walls where they form the corner.

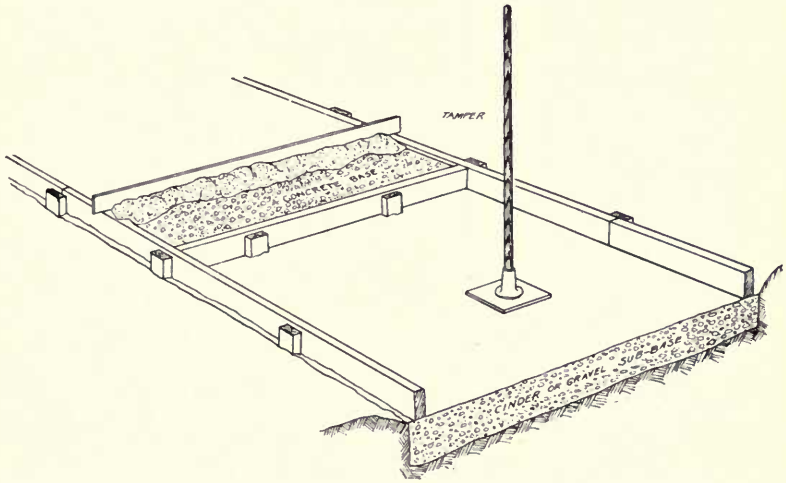
SURFACE AREA (IN SQUARE FEET) OF CONCRETE SLABS OR WALLS OF VARIOUS THICKNESSES AND PROPORTIONS, THAT CAN BE MADE WITH ONE SACK OF CEMENT

Thickness of Slab or Wall in inches	CONCRETE MIXTURE				
	1 : 2 : 3	1 : 2 : 4	1 : 2½ : 4	1 : 2½ : 5	1 : 3 : 5
3	15.52	17.88	19.42	21.77	23.2
3½	13.31	15.33	16.65	18.67	19.9
4	11.64	13.41	14.56	16.33	17.4
4½	10.36	11.93	12.96	14.53	15.5
5	9.31	10.73	11.65	13.06	13.9
5½	8.46	9.74	10.58	11.86	12.6
6	7.76	8.94	9.71	10.88	11.6
6½	7.18	8.27	8.98	10.07	10.7
7	6.65	7.66	8.33	9.33	9.9
8	5.82	6.70	7.28	8.16	8.7
10	4.66	5.36	5.83	6.53	6.9
12	3.88	4.47	4.85	5.44	5.8
14	3.32	3.83	4.16	4.66	4.7
16	2.91	3.35	3.64	4.08	4.3

Setting Wall Forms.—Wall forms must be set up very carefully and braced true to line so that the finished concrete work will have an attractive appearance and also be true to line. As walls expose a large area to the air it is very necessary that the concrete be protected for a few days after placing to prevent rapid drying out. The forms may be left in place several days and the whole work wet down, or if forms are removed wet canvas, burlap or some such covering should be hung over them and be kept wet for several days.

WALKS, FLOORS AND PAVEMENTS

Walks, pavements and floors are similar classes of concrete work. Most of the principles that apply to one apply to the others. Concrete walks and other pavements should be laid on firm, well drained soil. The area where they are to be laid should be free from all vegetable matter. Grass and tree roots should be dug out and the soil firmly compacted by using a heavy tamper or roller. If the soil is one that holds water, that is, that does not drain quickly or readily after rains, then a tile line should be laid parallel with the walk, this drain being connected at intervals to some lower point that will serve as an outlet and lead water away from the soil under and surrounding the walk.

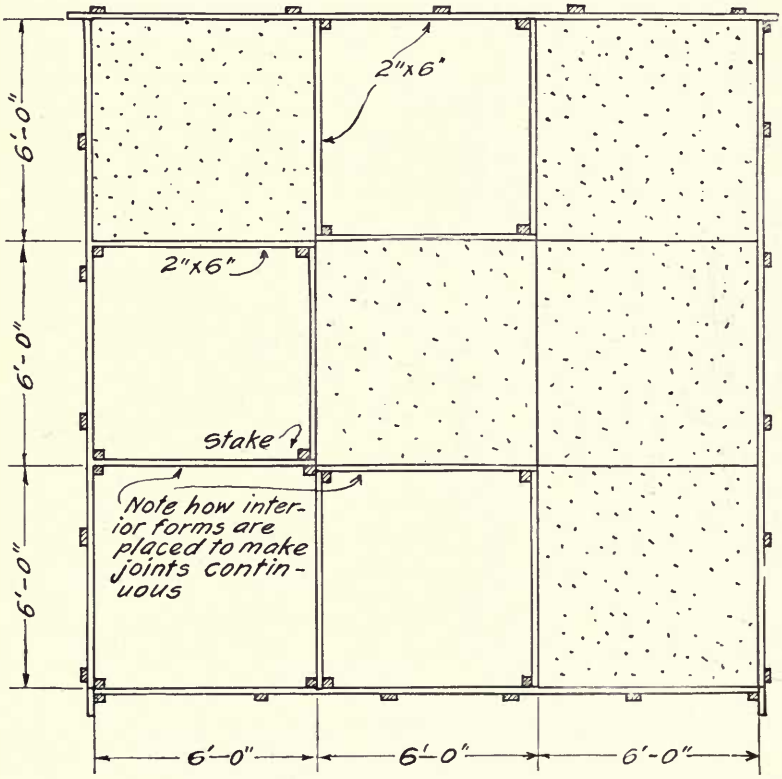


Forms for concrete sidewalk construction. The cinder or gravel subbase should be omitted except where the soil is of a kind that does not drain readily.

Foundation or Subbase.—In rare cases it may be necessary to provide a foundation for a concrete walk, pavement or floor by digging out the old soil and filling in from 8 to 10 inches with clean gravel or cinders. But this fill should not be used if it can be avoided. When necessary, however, such filling

should be well compacted and connected with tile drains at suitable intervals so that water will not remain under the concrete. If water were allowed to collect there, its freezing would cause upheaval of the walk due to expansion.

Size of Slabs.—For ordinary sidewalks, slabs should never be larger than 10 feet in any one dimension and preferably have a surface area no greater than 36 square feet. If larger it is best to embed suitable reinforcing in the concrete to



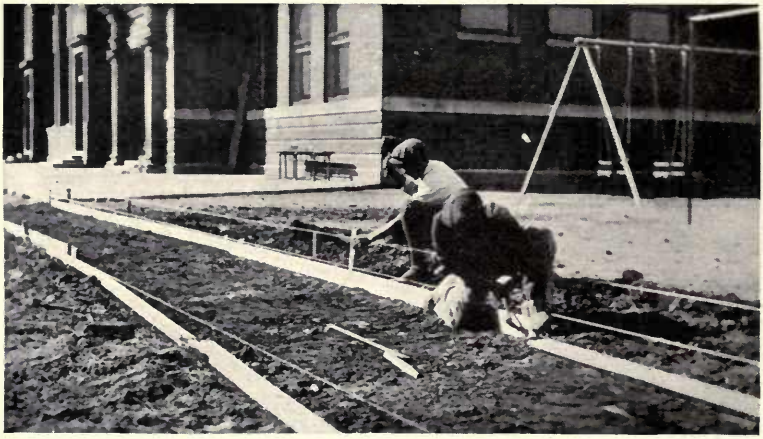
Method of setting forms to be used in building a concrete floor such as a hog feeding floor or barnyard pavement. These forms are so staked in position that alternate slabs can be concreted first, then forms removed so that the concrete previously placed serves in part as a form for placing the remaining slabs.

prevent cracking of the slabs from frost upheaval. Ordinary walks should be at least 5 inches thick. If they are ever to be used as driveways, then they should be at least 6 inches thick.

Types of Construction.—Walks, floors and pavements may be of one-course or two-course construction. For most work, one-course construction will be found best. One-course construction means that the same mixture of concrete is placed at one operation to the required thickness of the walk, pavement or floor. Two-course construction means that a mixture leaner in cement, that is, having less cement to each definitely

Tamping subbase for sidewalk foundation.

proportioned batch, is used as a base and on top of this a richer top or wearing course is placed. (See Table of Recommended Mixtures.) In two-course work it is very important that the top coat or wearing course be placed immediately after the base concrete is placed, otherwise the two courses will not bond or adhere to each other. For that reason, one-course construction is preferable.



Setting up and staking forms to proper grade and line for a concrete sidewalk.

Tamping concrete for the base of a concrete sidewalk.

Using strikeboard to level concrete of the base for a sidewalk.

Placing and striking off the top or wearing course of a concrete sidewalk.

Smoothing up the surface a little with a steel trowel. Too much troweling will make the surface slippery. A wood float finish is better.

Using a jointer to properly finish the joint between adjoining slabs.

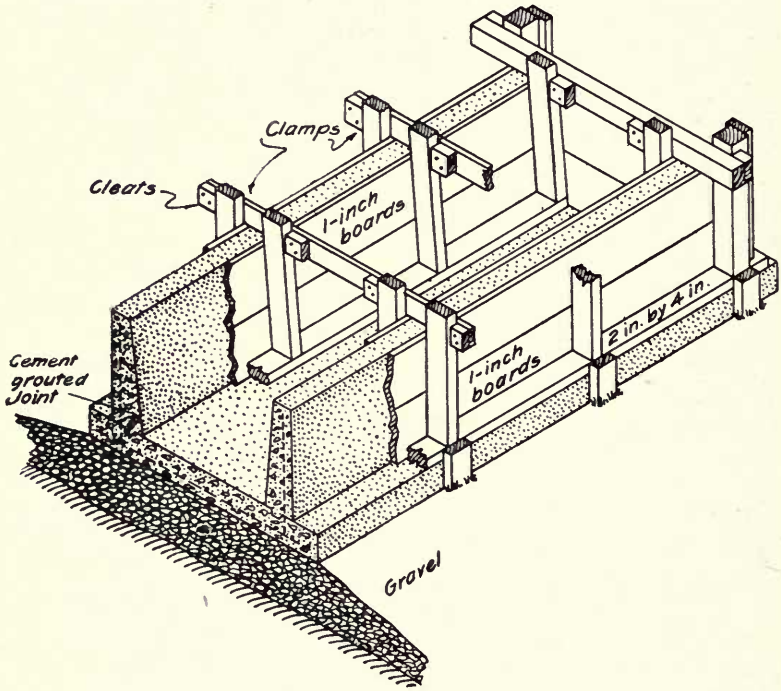
Finishing edge of the walk with an edger.

Finishing Methods.—In the past it was common practice to finish concrete walks and pavements to a very smooth surface. This proved objectionable from a number of standpoints, principal among which was the one that such a surface was slippery at times to walk upon; also, the wearing surface was made less durable because excessive troweling with a steel trowel brings considerable cement to the surface. Common practice now is to finish walks, floors and pavements with a wood hand float which, while giving an even surface, gives one that has a slightly gritty texture and thus affords a good foothold.

CONCRETE TANKS

Advantages of.—Concrete tanks have many advantages over those built of other material. Concrete will neither rust nor rot and can easily be kept clean. Of course the prime essential of a tank, trough or any receptacle that is to hold liquids is that it shall be watertight. A 1:2:3 concrete mixture should be used. Generally speaking, in thin sections the pebbles or particles of broken stone should not be larger than ½ or ¾ inch.

Some Important Principles.—After having selected clean, well graded materials and mixed them in correct proportions,



Forms and other details for building a concrete watering trough. Small troughs like this can readily be cast upside down in the same manner as small concrete flower boxes are made.

enough water must be added to the combined materials to make a concrete of quaky or jelly-like consistency. This mixture must be thoroughly spaded when placed in the forms so as to produce a dense, watertight mass with a smooth surface. It must especially be well spaded next to the form faces.

Methods of Placing Concrete.—Small troughs or tanks can be readily cast or molded upside down just as are some of the small flower boxes illustrated elsewhere in this book. When building concrete tanks or troughs it is best to carry on the work from start to finish without stopping, so there will be no construction seams to cause leakage.

Forms, and Concreting Details.—Forms for rectangular troughs or tanks are easier to make than for round ones, therefore the rectangular shapes are preferred by most people who do their own concrete work. Forms are shown for such a tank, a portion being cut away to illustrate them filled with concrete. The inside face of the tank walls is sloped to make the walls thinner at the top than at the bottom. This helps to relieve pressure from ice if water in the tank freezes. The illustration shows a method of construction that allows stopping work when the top of the floor level is reached. To prepare for resuming work later, a groove is formed in the floor by pressing a piece of beveled wood into the concrete all around the floor on a line corresponding to the center of the side and end walls. When concreting is resumed the beveled strip is removed, the concrete brushed and scrubbed clean and painted with a cement and water paint mixed about as thick as cream. Concrete is then placed before this paint can commence to harden.

In tanks or troughs of this kind, provisions are usually made for water inlet and outlet pipes. Great care should be taken when setting such pipes to make certain that the concrete is thoroughly in contact with the pipe fittings, thus preventing leakage.

CONCRETE POSTS

Concrete posts are made of various sectional shapes but square and rectangular sections are most common. In a fence post the strains are greatest at ground level. If one pushes hard against the top of a post, the concrete on the side where the force is applied is in tension, or is resisting a strain that tends to pull it apart at the ground line, while the concrete on the opposite side is in compression, or is resisting a crushing strain. This has been explained elsewhere in the discussion of the principles of reinforcing concrete.

How to Reinforce Posts.—Reinforcement is placed in a concrete fence post so as to give it additional strength and at a point as near the outer surface of the post as possible because the outer surface is the first portion of the post that has to resist this tension or bending strain. Reinforcement placed at the center of a post is of very little value unless the amount used is relatively excessive. A small but proper quantity correctly placed near the surface is much more effective. If the post section is round the four rods should be in position in the concrete corresponding to the corners of the square. In posts of square, rectangular or triangular sections the rods should be near each corner.

Tables of Materials.—Accompanying tables give various dimensions for posts, also the reinforcing required. It will be noticed that round rods are specified. Attention is called to this because many persons think that ordinary wire is suitable for reinforcement. This is true only in part, which is when the cross-sectional area of the wires used equals the corresponding cross section of the rods for which substituted. Barbed wire and similar scrap material should not be used as reinforcing because it is difficult to place and it is not certain that the required amount of reinforcement will be used.

Types of Post Molds.—There are many types of fence post molds on the market, and while it is perfectly practicable to

Table 1

Dimensions of concrete line posts, and materials needed

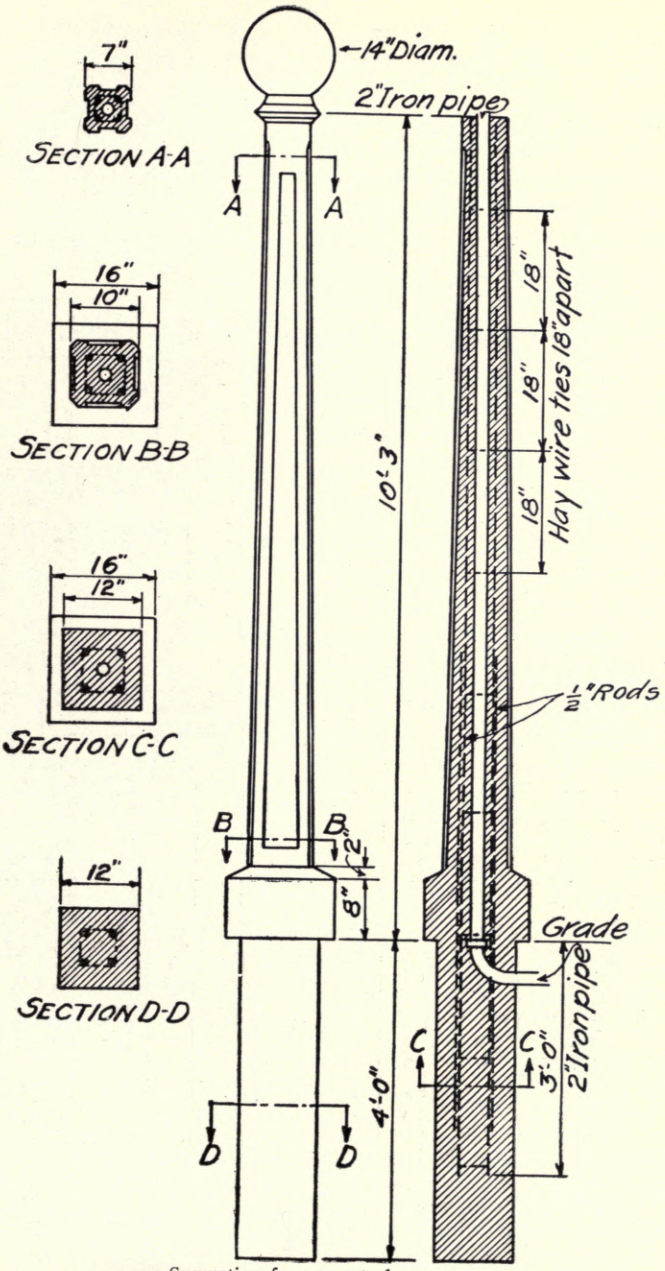
DIMENSIONS			Volume of Post in Cubic Feet	Weight of Post in Pounds	Amount of Reinforcing Metal Required	MATERIALS						
						1-Cement 3-Sand			1-Cement 2-Sand 3-Stone or Pebbles			
						No. Posts Per Barrel Cement	For 10 Posts		No. Posts Per Barrel Cement	For 10 Posts		
Length	Top	Bottom					Sacks Cement	Cu. Ft. Sand		Sacks Cement	Cu. Ft. Sand	Cu. Ft. Pebbles or Stone
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
6′ 6″	3″x3″	5″x5″	.7	107	Four	15.1	2.6	7.9	21.1	1.9	3.8	5 8
7′ 0″	3″x3″	5″x5″	.8	115	¼″	14.0	2.8	9 5	19.5	2.1	4.2	6.2
7′ 6″	3″x3″	5″x5″	.85	123	Round	13.2	3.0	9.1	18.4	2.2	4.4	6.6
8′ 0″	3″x3″	5″x5″	.9	131	Rods	12.3	3.2	9.7	17.1	2.4	4.7	7.1
6′ 6″	4″x4″	5″x5″	.9	133	Four	12.2	3.3	9.8	17.0	2.4	4.8	7.2
7′ 0″	4″x4″	5″x5″	1.0	143	⅛″	11.3	3.5	10.6	15.8	2.6	5.1	7.7
7′ 6″	4″x4″	5″x5″	1.05	153	Round	10.6	3.8	11.3	14.7	2.8	5.5	8.2
8′ 0″	4″x4″	5″x5″	1.1	163	Rods	9.9	4.0	12.1	13.8	2.9	5.9	8.8
6′ 6″	5″x5″	6″x6″	1.4	197	Four	8.2	4.9	14.6	11.4	3.6	7.1	10.6
7′ 0″	5″x5″	6″x6″	1.5	213	⅜″	7.6	5.3	15.8	10.6	3.8	7.7	11.5
7′ 6″	5″x5″	6″x6″	1.6	228	Round	7.1	5.6	16.8	9.9	4.1	8.2	12.3
8′ 0″	5″x5″	6″x6″	1.7	243	Rods	6.6	6.0	18.0	9 2	4.4	8.8	13.2

Table 2

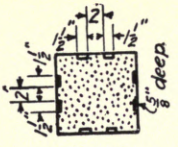
Dimensions of corner posts and materials needed

DIMENSIONS		Volume of Posts in Cu. Ft.	Weight of Posts in Pounds	Amount of Reinforcing Metal Required for Each Post	MATERIALS						
					1-Cement 3-Sand			1-Cement 2-Sand 3-Pebbles or Stone			
					No. Posts Per Barrel Cement	For 1 Post		No. Posts Per Barrel Cement	For 1 Post		
Length	Size					Sacks Cement	Cu. Ft. Sand		Sacks Cement	Sand Cu. Ft.	Pebbles Cu. Ft
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
8′ 0″	6″x 6″	2.0	288	Four	5.6	.7	2.1	7.8	.5	1.0	1.6
8′ 0″	7″x 7″	2.7	392	⅛″	4.1	.95	2.9	5.7	.7	1.4	2.1
8′ 6″	7″x 7″	2.9	416	Round Rods	3.9	1.0	3.1	5.4	.8	1.5	2.2
8′ 0″	8″x 8″	3.6	512	Four	3.1	1.3	3.8	4.4	.9	1.8	2.8
8′ 6″	8″x 8″	3.8	544	⅛″	3.0	1.35	4.0	4.1	1.0	2.0	2.9
9′ 0″	8″x 8″	4.0	575	Round Rods	2.8	1.4	4 3	3.9	1.1	2.1	3.1
8′ 0″	10″x10″	5.6	799	Four	2 0	2 0	5 9	2 8	1.4	2.9	4.3
8′ 6″	10″x10″	5.9	850	⅛″	1 9	2.1	6.3	2.6	1.5	3.1	4.6
9′ 0″	10″x10″	6.2	899	Round Rods	1 8	2.2	6.7	2.5	1.6	3.2	4.8
10′ 0″	5″x 5″	1.7	250	Four ¾″	6 4	6	1 9	9.0	.4	.9	1.4
12′ 0″	5″x 5″	2 1	300	Round Rods	5 4	7	2 2	7.5	.5	1.1	1.6

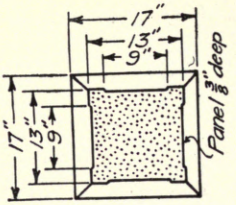
Two attractive types of concrete lamp posts. The principles of post manufacture apply to these as to other types of concrete posts. Much of the attractiveness of such concrete work comes from the surface finish given to it after forms have been removed.



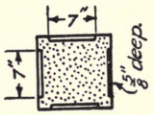
Suggestion for concrete lamp post.



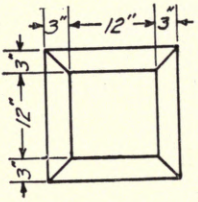
Section on B-B.



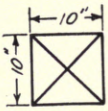
Section on A-A



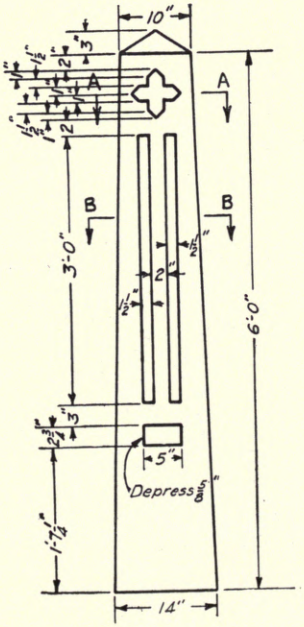
Section on A-A



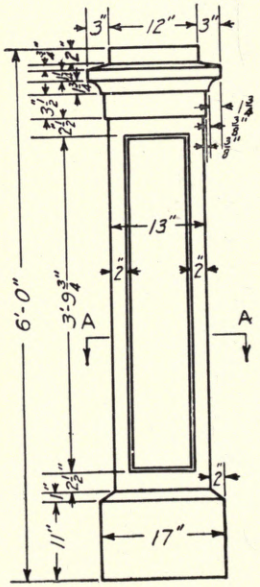
Plan of Top.



Plan of Top.



Elevation.



Elevation

Designs for gate posts.

make a wood mold for concrete fence posts, it is in general best to use some one of the commercial types of molds. In making wood post molds only clear, straight-grained lumber should be used. To prevent the pieces of which the mold is constructed from warping or bulging out of shape due to moisture absorbed from the concrete, the lumber should be saturated with a mixture of equal parts of boiled linseed oil and kerosene. The surplus should be wiped off before placing concrete. Wetting the mold just before placing the concrete will be an additional precaution against the concrete sticking to it.

Concrete Mixture for Posts.—A 1:2:3 mixture is used for concrete fence posts. Pebbles or broken stone should not be larger than ½ inch. The mixture should be slightly wetter than the one described as quaky, but not so wet the pebbles will separate from the sand-cement mortar. After the molds have been oiled, 1 inch of concrete should be spread evenly at the bottom, then two reinforcing rods of the proper size and length should be laid in the concrete at the correct distance from the sides of the form. These rods should be pressed gently into place and held a proper distance from each other and from the sides of the mold by passing over them four or five wire spacers. A piece of hay baling wire looped around the rods will serve the purpose. Additional concrete may then be placed up to within ¾ inch of the top of the mold, when the remaining two rods, also with spacers over them, should be placed exactly as were the first two. The remaining space in the mold should then be filled with concrete and the surface smoothed with a wood trowel.

To make a post that will have a smooth surface and dense structure it is necessary that while the concrete is being placed any air that may have been trapped in it by mixing be forced out. Various types of commercial fence post molds are filled by one of two methods. Sometimes the molds are set up on one end and filled from the other. In other cases the molds

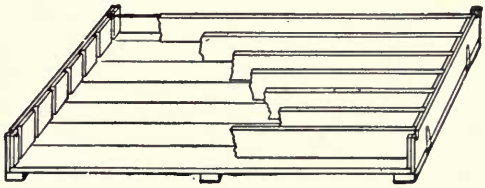
are open at one side and are filled while lying in a horizontal position. When the former type of mold is used the air bubbles can be forced out by repeatedly raising and dropping the mold while the concrete is being placed or by stirring the concrete slightly with a stick or rod, tapping the mold while filling it. In the latter case the mold may be shaken, jarred or rapped or a thin stick or rod dragged through the concrete and along the inside surface of the mold, thus helping to release the air bubbles. These methods properly used will, if the concrete mixture is of the right consistency, give a dense post, with a smooth surface finish showing few if any pebble or air pockets.

After molds have been filled they must remain undisturbed until the concrete has hardened sufficiently to permit removing the posts from the molds without damaging them. Under favorable conditions such as prevail during summer weather, the side pieces of the mold may be removed at the end of twelve hours. It is important that the concrete shall have hardened sufficiently so that when removing the molds the concrete will not be injured. For this reason a wood mold should be built so that wedges and blocks only will be necessary to hold all parts assembled, thus making it possible to take the mold apart with the least amount of hammering. After a post is made it must be given time to harden and gain strength before being used. In other words, it must be "cured." This is done by keeping it damp for several days. A covering of hay or straw and frequent sprinkling during each day for at least a week will accomplish the purpose.

In regular manufacturing plants where concrete posts are made commercially, they are usually cured or hardened by steam, which properly used will accomplish as much in 48 hours as can be done in a week or more by the sprinkling method. But as steam hardening cannot usually be arranged for outside of the commercial plant, it will not be discussed in detail here.

After a post has been kept moist by a protective covering properly sprinkled for a week or more, it will be strong enough to be moved if handled carefully. No post should be subjected to the strains of a fence line until it is at least a month old. Weather is an important factor in the hardening of concrete. The speed of hardening is much more rapid in mid-summer than at other seasons, and when the temperature is near freezing the rate of hardening is very slow, therefore the time of hardening must be lengthened in accordance with the season and weather conditions. Posts made during cold weather must be protected from freezing until thoroughly hardened, as must any other concrete work under the same conditions.

Corner and gate posts are always more massive than ordinary line posts and as a rule these larger posts are cast in place by first making the proper excavation, then setting up the necessary forms, placing reinforcing and depositing concrete from one end of the mold. If the post is to be used for hanging a gate, suitable provisions must be made in the mold and while placing concrete to embed in it the necessary gate hanging fittings. Also, such a post should be allowed to stand for 30 days or more until it has gained sufficient strength to allow hanging the load of the gate upon it.



Home-made wood forms for fence posts.

CONCRETE BLOCK

Probably concrete block have been responsible in a greater measure than any other use of concrete for the popularity of concrete construction. Unfortunately, however, many of the early concrete block made were poor imitations of stone face and still poorer examples of concrete. The trouble lay largely in the fact that those who made them had little or no knowledge or regard for good concrete practice. Too little cement was used, the materials were not correctly proportioned, and so little water was used that the blocks were soft and porous.

Block Machines.—Concrete block are best made in some one of the commercial machines intended for that purpose. A type of machine should be used that will permit of just as wet a concrete mixture as possible, otherwise there will not be enough water in the concrete to cause it to properly harden. Desire to turn out a large output tempts many persons to use too little water in the concrete. The mixture is barely more than damp while it should be wet enough so that when a handful of the mixed concrete is squeezed, a few drops of water will trickle from it.

Mixture to Use.—Depending somewhat upon the character of the aggregate, concrete for the body of block should be mixed in the proportions of 1 sack of Portland cement, 2½ cubic feet of clean, coarse sand graded in size up to ¼ inch, to 4 cubic feet of hard pebbles or broken stone ranging from ¼ to ¾ or 1 inch. When the block are faced, the facing mixture should be in the proportions of 1 sack of Portland cement to 2 cubic feet of sand or whatever other material, such as crushed granite, marble chips, etc., is used as aggregate. Block having very pleasing texture surface finish can be made by following the practices outlined elsewhere in discussing surface finishes of concrete. It is important that block and similar products be properly hardened, and steam hardening or curing, which is explained in another section, is best.

FORM DETAILS AND PRACTICAL DESIGNS

Plate 1 illustrates some important details of form construction. The types of forms illustrated are simple. At the upper left-hand of the plate is shown a form with square ends made up of the four sides *a*. When the sides are withdrawn or removed from the object in the direction of the arrowheads there is no possibility of binding. Pieces *a* may be wider than the object is high and the mold filled only so full as necessary to come to the top of the object. In that way lumber need not be cut unnecessarily nor wasted.

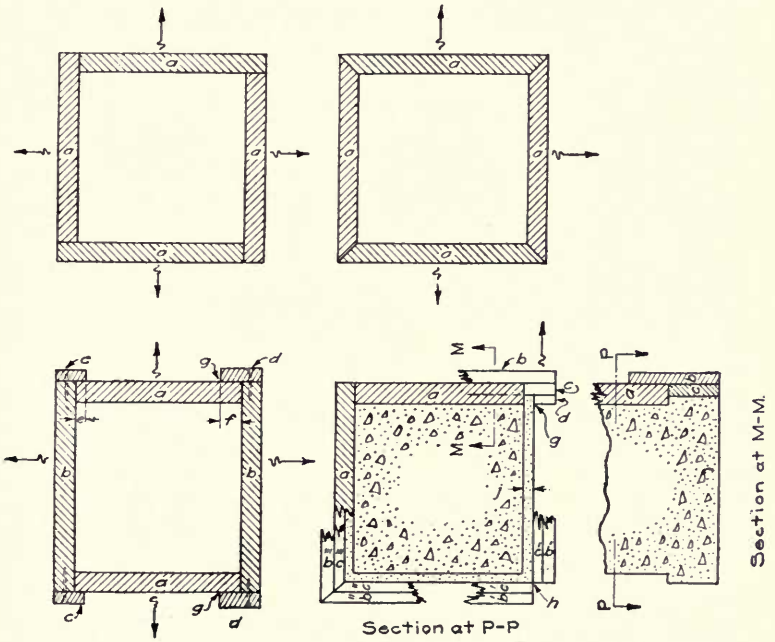


PLATE 1

At the upper right-hand portion of Plate 1 is a form composed of four sides, assembled by having the pieces *a* mitered at their ends. This type of form requires a little more care in mak-

ing in order that the miter be cut true. The use of forms of this kind is usually confined to concrete objects that have projecting surfaces which would prevent the sides *a* from being withdrawn or removed in the direction of the arrowheads.

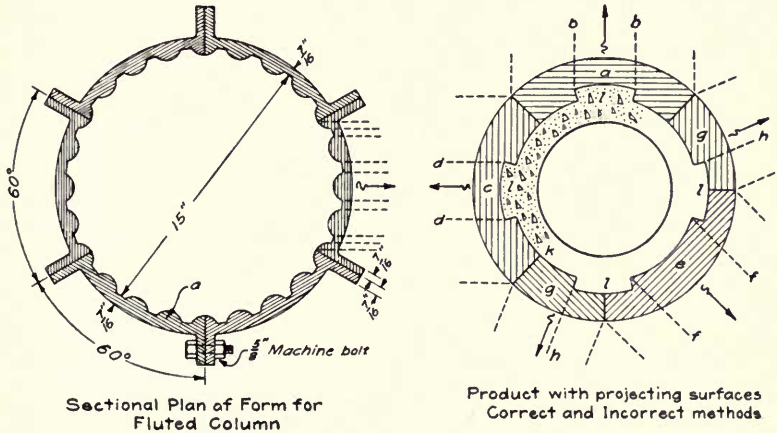
At the lower left-hand portion of Plate 1 are various details of a form with squared ends composed of the sides *a* and *b*. Sides *b* have cleats *c* and *d* nailed to their ends. These serve to hold sides *a* securely in position while concrete is being placed. Cleat *c* should not overhang or project beyond side *a* any more than necessary. It should have a good bearing surface on side *a*. This will permit withdrawing side *b* in the direction of the arrowheads with the least amount of binding or sticking due to swelling of the wood when the parts are wet. If the overhang of cleat *c* is as great as shown in cleat *d* greater difficulty will be experienced in withdrawing side *b* because of this large overhang as shown at *g* and *f*.

At the lower right-hand portion of Plate 1 is a form illustrating a case where it is sometimes necessary to use a combination of squared ends and mitered joints. As shown, the upper part consists of four sides *a*. The lower portion of the form consists of pieces *c* and *d* which are nailed together while the piece *b* is nailed to piece *a*. If mitered joints were not used at the lower portion of this form it would take the shape as shown in the upper right-hand corner of section *P-P*. The part *d* would have to be nailed to parts *c* and *b* in order to secure the required surface finish at *g*. Such a form when withdrawn in the direction of the arrowhead would bind on the object at *g* and would be difficult to withdraw without injuring the corners of the concrete. This, however, could be overcome by cutting off the ends of the pieces *b* and *c* as shown in the lower left-hand corner of section *P-P* with pieces *b'* and *c'* meeting at the corner and leaving the open space *h*. This arrangement would form a true edge for the concrete product and the forms could be removed without difficulty. However, unless the joint at *h* were tight it would allow water carrying cement to leak out of the form. To prevent

this, pieces *b* and *c* are carried out and mitered as shown at *b''* and *c''* at the lower left-hand corner of section *P-P*. Mitered joints should be used in every case where there is even a slight projection beyond any one surface of the concrete object.

Division of Forms.—As mentioned elsewhere some forethought must be given to planning forms for concrete objects having unusual shapes, and in such planning care should be taken to arrange to divide the forms into sufficient parts to make removal from the object easy.

Plate 2 shows some such details. At the left of the plate is a form for a column having twenty-four flutes. In this case it is necessary that the form be divided in six sections so that each may be withdrawn in the direction of the arrowhead without binding at any point. The dotted lines parallel to the direction



Sectional Plan of Form for Fluted Column

Product with projecting surfaces Correct and Incorrect methods

PLATE 2

of the arrowhead show that the form will clear all flutings without injuring the edges. In this particular case the flutings are shallow. If they were deeper these sections could not be withdrawn without injuring the edges. In such a case the form would have to be divided into more than six sections.

It is always necessary first to lay out the column in plan to determine the number of sections required. The form which is described is supposed to be of cast iron. The sections are bolted together. Although it is possible to make such forms of wood it involves considerable work and owing to the tendency of wood to swell when wet, metal forms are more practicable for repeated use where high-grade work is required.

At the right of Plate 2 there is shown in section a form for a product having projecting surfaces such as pilasters or lugs. The form is shown partly filled with concrete to illustrate the object *k*. There is a correct and an incorrect way of making forms for such objects. Segment *e* has joints at the middle points of projections *l*. When withdrawn in the direction of the arrowhead the form will clear the concrete as is indicated by the parallel dotted lines *f-f*. This is the correct method if the form is divided into four segments similar to *e*. If the form is divided into four segments similar to *a* having the joints midway between two projections the segments cannot be withdrawn in the direction of the arrowhead, nor in any other direction, without breaking the edges of the projection as shown by the parallel lines *b-b*. If the edges of the projection on the product are parallel with the line drawn through the center of the product as shown at *c* then joints midway between the projections would be permissible and the form could be divided into four segments similar to *c*. These segments could be withdrawn in the direction of the arrowhead as indicated by the dotted lines *d*. If the form were divided into eight parts then each part would be similar to segment *g* which could be withdrawn in the direction of arrowhead without injuring the edges of projections as shown by line *h* parallel to the face of this projection.

The foregoing examples illustrate the underlying principles of correct and incorrect methods of dividing forms for practically all circular concrete objects. Other objects will require only a variation of these principles, to conform to the shape of the object.

Plate 3 illustrates details of a form for solid concrete block 9 inches square by 10 inches high. This form may be built of 1 or 1½ inch lumber. The ends of the sides *a* should be square. The ends of the sides *b* have cleats nailed to them as shown at *c*. These cleats hold sides *a* securely in position while concrete is being placed in the form. Sides *b* are held in position either by metal clamps and wedges, or by any one of the numerous commercial

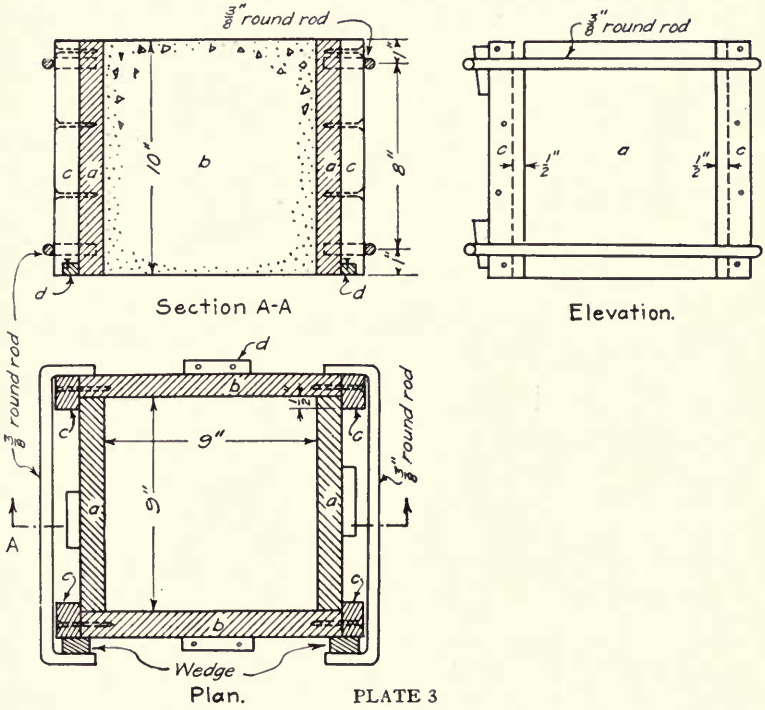


PLATE 3

clamps such as used by wood workers for holding pieces together while gluing. When assembling a form the four sides are set up on a workbench or table to which blocks *d* are nailed in position to hold the form square. When blocks *d* are attached to the workbench, nails should not be driven all the way in. This will permit

pulling them easily without hammering or blows that would injure the concrete.

Cores.—A form such as shown can be used for the exterior form of a square flower box. Of course a core or inside form is then required. Although the core may be made of a solid block of wood tapered so as to permit withdrawal, this is

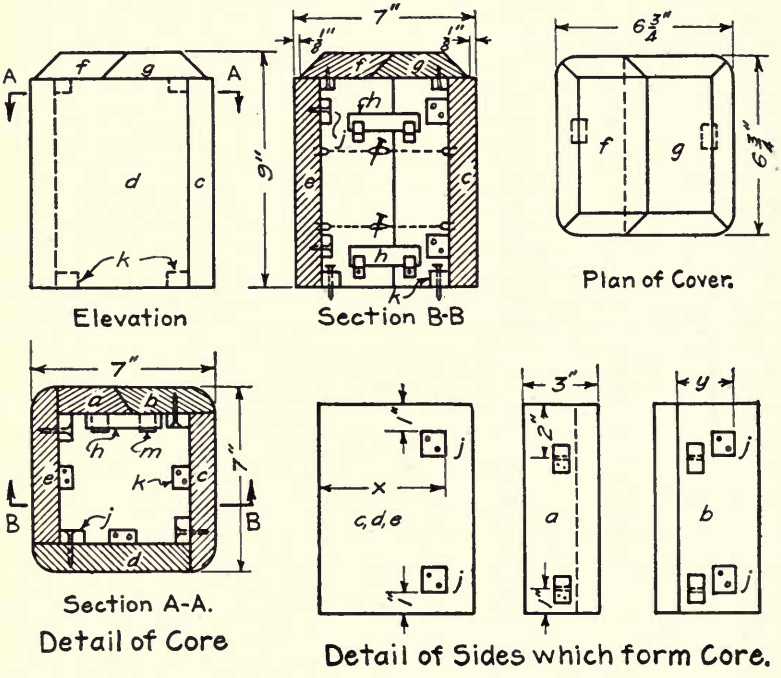


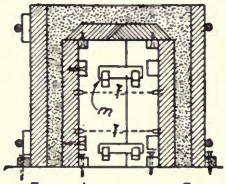
PLATE 4

not good practice as the block is almost certain to swell and be difficult to remove.

Cores similar to those shown in Plate 4 should be used. They require no taper since they are planned particularly with a view to easy removal. Sides *e*, *d* and *c* are similar in every respect. Parts *a* and *b* have beveled or splayed edges, so that

when knocking down the core the cleat *h* may be withdrawn from the metal brackets *m* and the side *a* easily removed. The sides *e, d, c,* and *b* are then successively withdrawn. Sides *c, d, e,* and *b* are fitted with blocks *j* to hold the core form square. Blocks *k* are nailed to the workbench when the form is set up to hold the core centered.

Plate 5 shows a form such as described assembled and with concrete in place. Similar core forms are used for square hollow columns or piers. A small flower box like this is cast bottom side up, that is, the top of the mold is the bottom of the object. Attention should be drawn here to the distinction between the bottom of the object and the bottom of the form. That part of the form which rests upon the workbench or upon the platform upon which the work is being done will hereafter be referred to as the bottom of the form, while the bottom of the concrete object being described will always be referred to as the bottom regardless of its position when being cast.



FORM ASSEMBLED SHOWING CONCRETE IN PLACE

PLATE 5

Plate 6 shows various details of a solid knock-down core. Such a type of core or inside form may often be used to advantage in small concrete products. Completely assembled, the form consists of a solid block of wood with rounded or beveled corners at the top and side edges. This is then cut into four blocks as shown. The top view of this core illustrated at section *A-A* shows how the blocks are numbered. Numbers to correspond with those on the tops of the various pieces should also be placed on the bottom so that when the mold is reversed

the core may be withdrawn. Section No. 1 is withdrawn first, then No. 3, then No. 2, then No. 4. The importance of numbering the pieces and the order in which the blocks should be withdrawn must be impressed upon the worker. The four blocks are held assembled by fine wire or string. The underside of

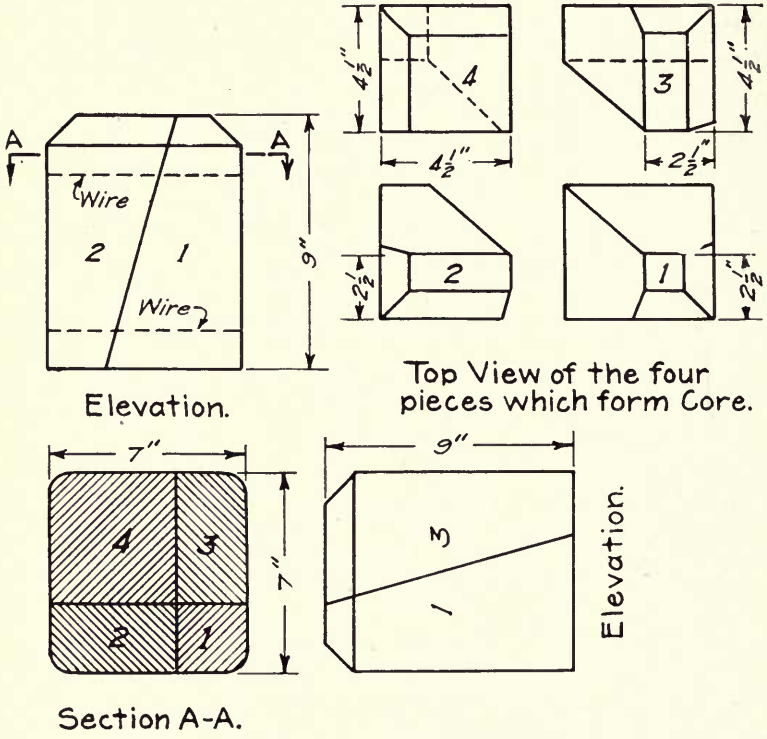
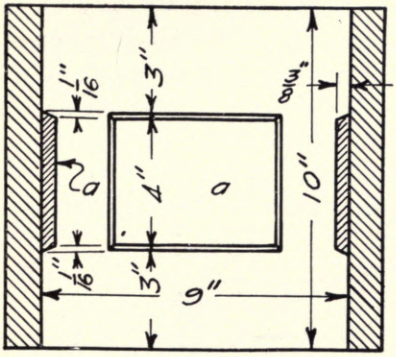
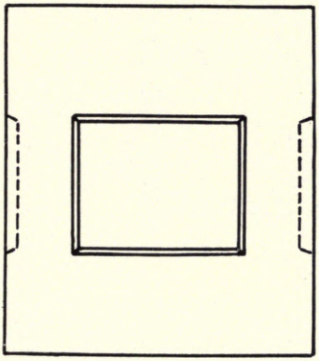


PLATE 6

the core should be bored with small holes which will snugly receive corresponding dowel pins or nails set in the workbench. These pins or nails will prevent side movement or shifting of the core.



Section.



Elevation.

PLATE 7

Plate 7 illustrates a form for solid block or a flower pot which introduces slight decoration in the form of depressed panels. The exterior form is the same as that shown in Plate 3 except that thin pieces of wood are nailed on the inner surface of the form as shown at *a* to provide for depressed panels in the finished object. Small brads or finishing nails should be used for this purpose and countersunk with a nailset, the head-holes being then filled with putty so that nail hole markings will not appear on the finished concrete. The pieces *a* should have a slight draft or bevel around edges, say, about 1-16 of an inch, so that the form may be withdrawn without injuring edges of the depressed panel.

The next elaboration of this simple form is to vary it for casting an object with raised panels as shown in Plate 8. Instead of nailing pieces on the inside face, as described in the last plate, pieces *x* are properly attached to the interior face of the forms. It is important that the ends *b* and *c* be made square as shown, but the ends of pieces *x* must be mitered. If not mitered the form cannot be withdrawn from the concrete without injury to the surface.

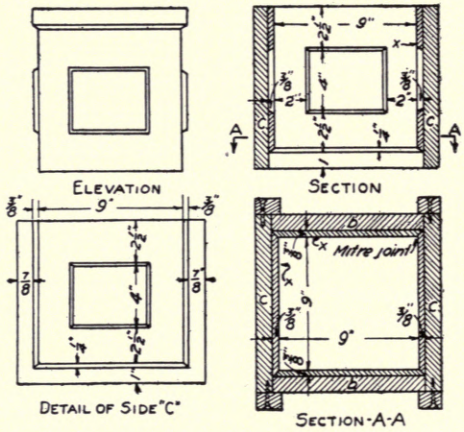
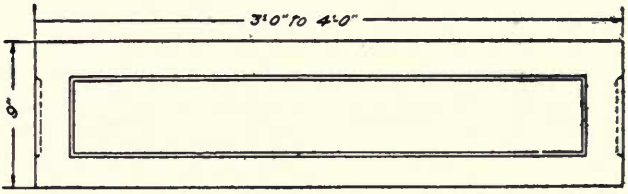


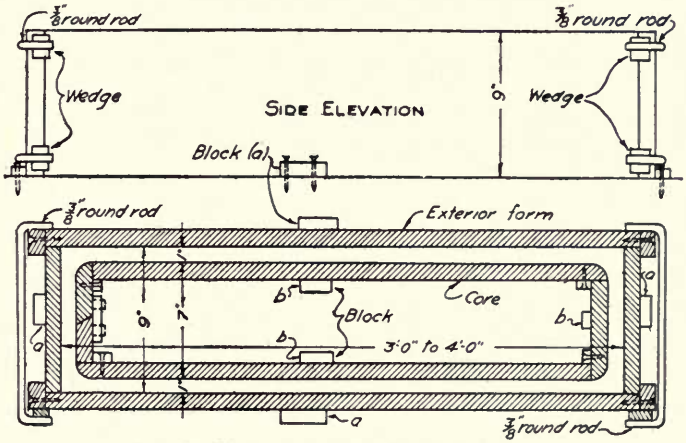
PLATE 8

Forms of this kind may be elaborated in various ways to serve for square columns and piers which it is desired shall have either depressed or raised panels.

Plate 9 shows various details of a rectangular form for a flower box. Such forms are similar in every respect to the simple square forms previously described. In order to prevent the sides of the form from bulging in or out when placing or tamping concrete, braces should be placed at convenient points along the sides. These will keep form pieces properly lined up. Blocks *a* and *b* are nailed to the workbench to keep the outside form and core from shifting.



SIMPLE BOX WITH DEPRESSED PANEL



PLAN OF FORM AND CORE ASSEMBLED

PLATE 9

At the upper portion of Plate 9 a variation of form is shown whereby raised or depressed panels may be provided for.

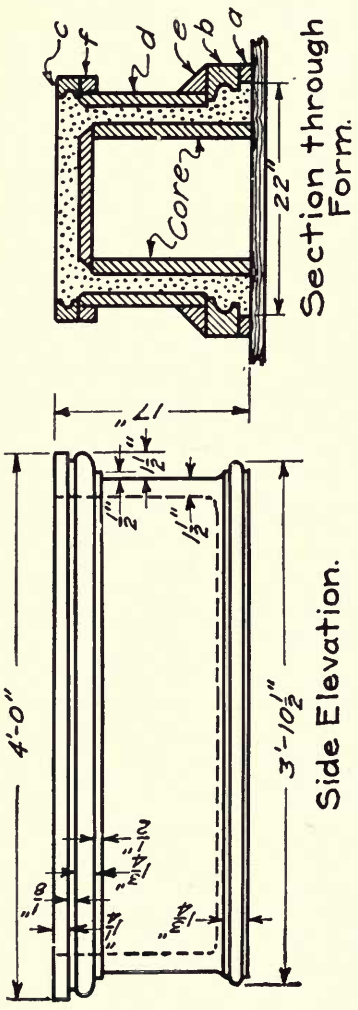
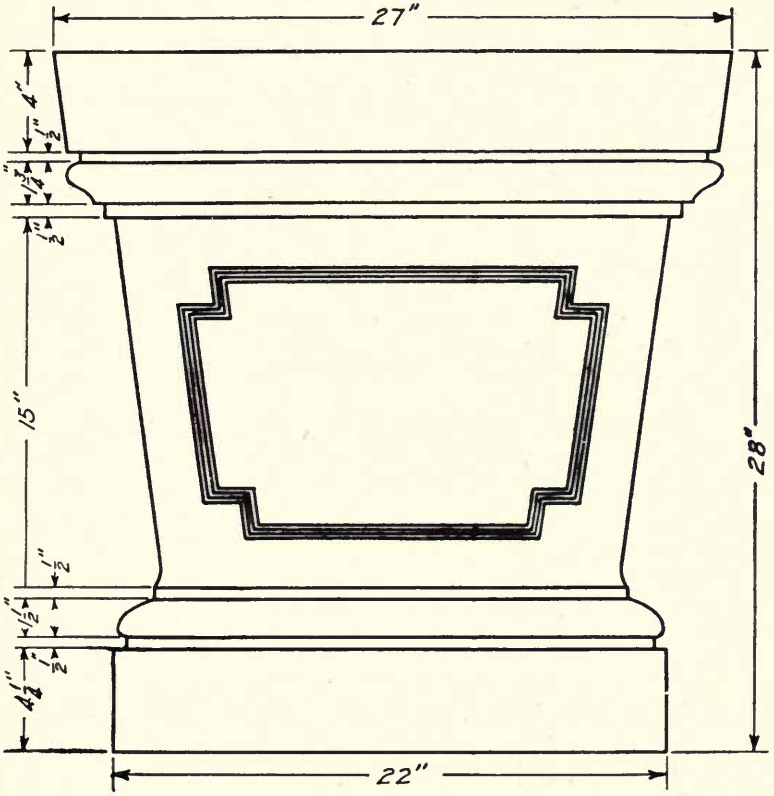


PLATE 10

Plate 10 is a slight elaboration of the design shown in Plate 9, in that a different kind of ornamentation is provided for in making the form. The core and other details of the form are in general like those previously described. The parts *a, b,* and *c* which provide for the ornamental molding on the concrete object may be built up as shown in the sketch illustrating a section through the form. Because of overhang on the object the ends of the exterior form must be mitered. In preceding examples there was no such overhang, hence the sides of forms did not overlap a corner of concrete and could readily be withdrawn. Unless the mitered joint is made in this case it is practically impossible to remove forms without injuring the object. Pieces *b* and *c* may be made of stock molding or trim and nailed to the remainder of the form, or they may be formed from suitable pieces of wood in a wood-working shop. Parts *a, b, c, d, e,* and *f* must be securely nailed together before the mitered joint is cut.

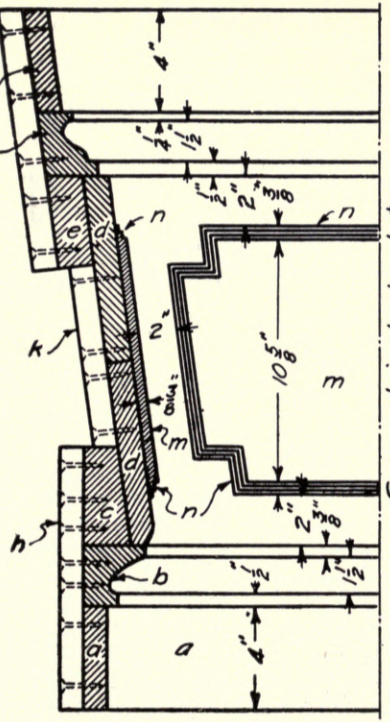
Plates 11, 12 and 13 show various details of a square ornamental flower box such as would be used for a small bay tree or rubber plant. A half section of the form is shown to the left of Plate 12 and makes clear how the separate parts of the



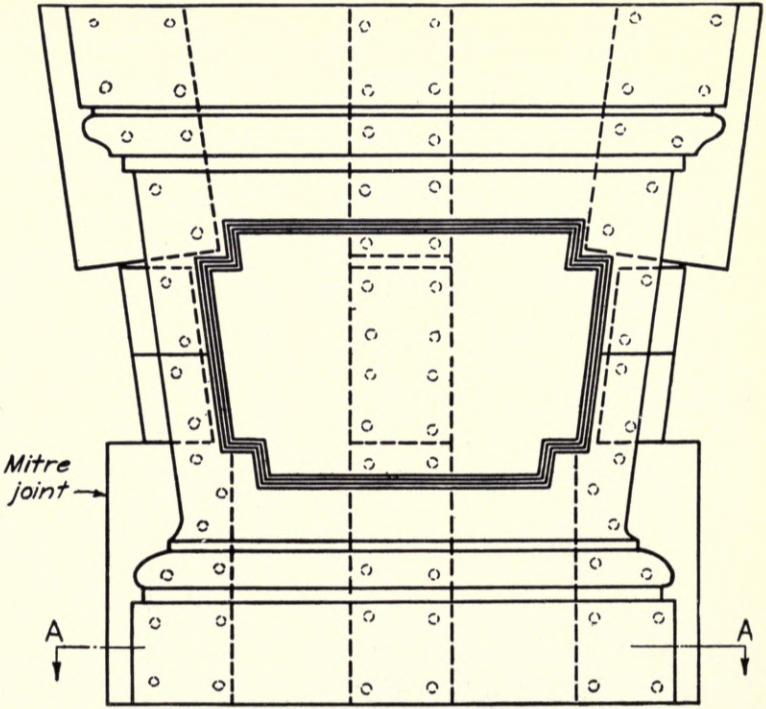
Elevation of Bay Tree Box.

PLATE 11

form are nailed or screwed together. Part *a* is made of ⅞ or 1-inch lumber, part *d* from stock molding, and inner face of *c* is cut to the slope of the side of the box. Part *d* is made of



Half Section through Exterior Form.



Interior Elevation of one Side of Form.

2 pieces of 1-inch stuff, part *e* of 2-inch stuff. Part *f* is made from stock molding, *g* from 1-inch stuff. Parts *a, b,* and *c* are held together by cleats *h*. The two pieces of lumber forming the side are held together by cleats *a* while the parts *e, f* and *g* are

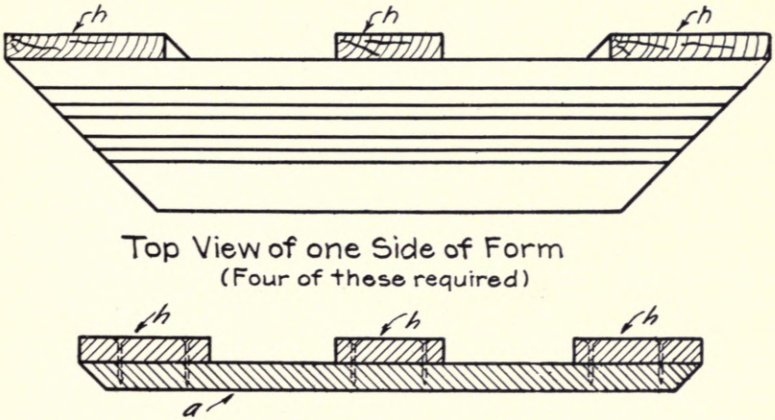


PLATE 13

held together by cleats *l*. The outer edge of the depressed panel *m* is formed by attaching small stock molding *n* to the pieces *d*. After all parts are nailed together the mitered joint is cut. This is shown in section and elevation at the lower portion of Plate 13.

By slight extension of use forms similar to those described for flower boxes can be used to build a plain round-topped table with square pedestal, the several parts being cast separately and later assembled. Details of this are shown in Plate 14. The

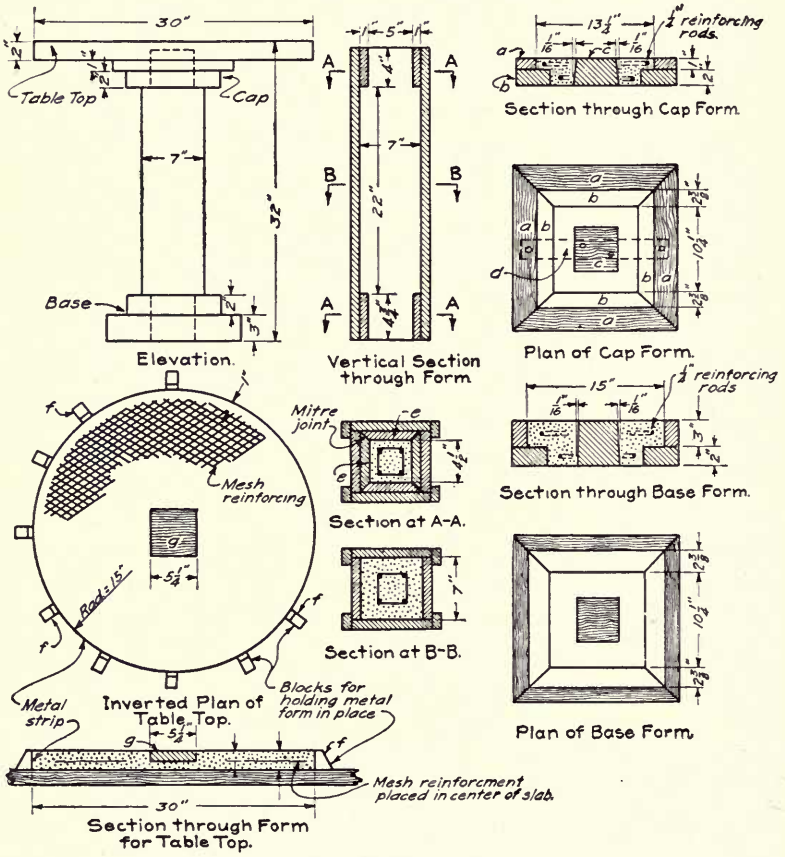


Table
With Top, Cap, Shaft
and Base
Cast Separately

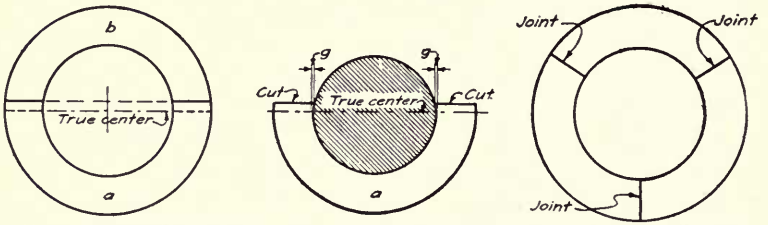
PLATE 14

first step is to make the cap form. Pieces *a* and *b* shown in the upper right-hand portion of Plate 14 are nailed together and a mitered joint cut. These four pieces thus compose the exterior form for the caps. Cut piece *c* 5¼ inches square with four edges beveled to allow a draft of 1-16 of an inch. This is the core, which is held in exact position by cleat *d* nailed to it and in turn tacked to the exterior form. The form for the base is made in a similar manner. The form for the shaft of the pedestal is made with square joint except at the sections *A-A*. Ordinarily no reinforcement is required in the shaft but to prevent possibility of injury from frequent handling it is well to insert small steel rods (¼ inch) or expanded metal in the concrete.

The form for the table top is made by first cutting a piece of thin metal 2 inches wide and 94½ inches long preferably in one piece. This strip is then bent around inside of blocks *f* which are nailed to the workbench with their inside edges on a line corresponding to the circumference of the table top. The ends of these metal strips should butt together and be nailed to one of the blocks *f*. Care should be taken not to dent nor otherwise injure the metal strip when setting it up and nailing it in position, otherwise the concrete surface against it will show any irregularities in the metal. Piece *g* forms the core for a 5¼ inch by 5¼ inch mortise in the underside of the table top or slab. This core is held in exact position by means of a cleat. Allowance has been made in the sketch for mortise joints where the tenon fits into the mortise. After the concrete has hardened the several parts of the table are assembled and held together by thin mortar previously spread over the parts to be joined.

Reinforcement for the table top may be suitable mesh fabric or expanded metal, preferably with mesh no larger than 1 inch in greatest dimension. It should be placed in the center of the slab and at no place should come nearer than 1 inch to the edge. Before making a table like the one just described and

having a cylindrical pedestal instead of a square one a word of caution may be given as to the requirements of form construction for the cylindrical portion. Frequently such forms are cut into two supposedly equal parts. Often, however, the cut is made so that the supposed halves are unequal, that is the cut is made slightly to one side or the other of the true diameter. This makes segment *a* as shown in Plate 15 larger than seg-



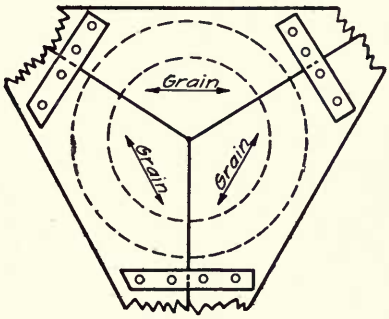
Incorrect method of making Joints for Circular Form.

Correct method of making Joints for Circular Forms

PLATE 15

ment *b*. Therefore segment *a* will cling to the object or cannot be removed without injury to the concrete. This is shown in the center sketch of Plate 15 with the exception that the drawing has been purposely made to exaggerate the curves so that the gripping of the form may be seen. The correct and sure method is to divide the form into three or more parts according to the size of object as shown at the right-hand portion of Plate 15.

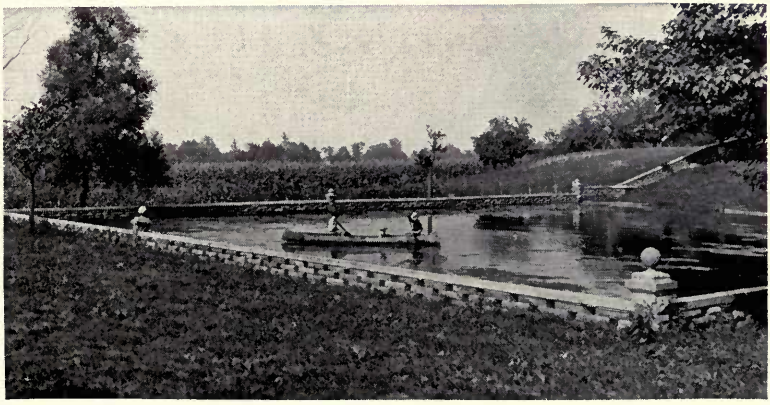
Plate 16 suggests the best manner of cutting wood so that the grain will run the long way of the pieces regardless of their number. The wood is cut into diagonal sections and fastened together with cleats as shown. The center is then sawed



Suggested Method for Cutting Cants with the Grain.

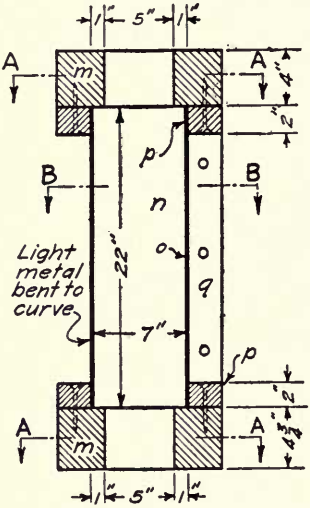
PLATE 16

out along the inner dotted circle. Then a saw cut is made along the outer dotted circle. To prevent splitting, pieces of this kind should be of at least 1½ or 2-inch stuff.

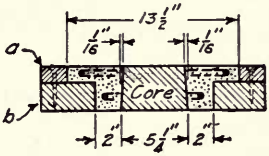


Fish pond, with concrete block wall, on an Indiana Farm.

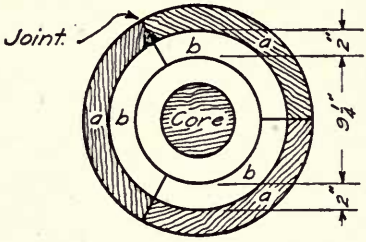
Plate 17 gives various details of forms for round-top table with cylindrical pedestal. The form for the top is the same as



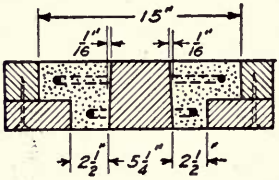
Vertical Section through Form.



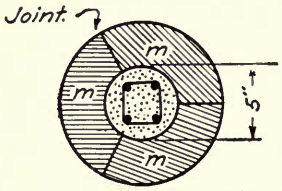
Section through Cap Form



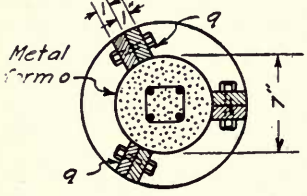
Plan of Cap Form.



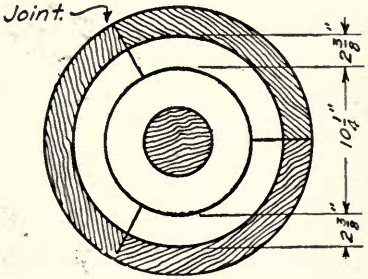
Section through Base Form



Section at A-A.



Section at B-B.



Plan of Base Form.

PLATE 17

that illustrated and described in connection with Plate 14. The form for the cap is built up of pieces *a* and *b*. The core is the same as for a square pedestal. Form for the shaft is built up of segments *m* and *n*. Sheet metal *o* is bent to the desired curve and attached to the uprights *q*. Joints of this metal should abut instead of overlap and should be smooth to prevent after markings on the concrete. Uprights *q* are clamped or bolted as shown. Pieces *p* are nailed or screwed to segments *m*.

Plate 18 shows design for round top table with cylindrical pedestal cast in one piece. Form for base of pedestal is made

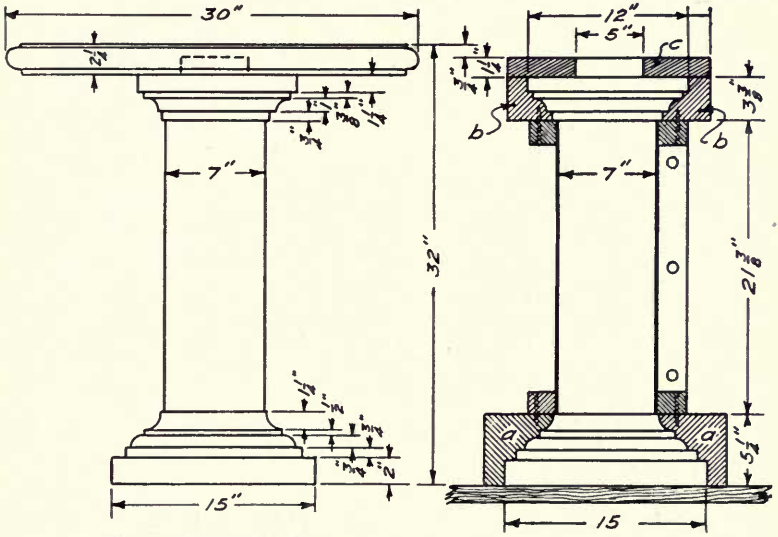
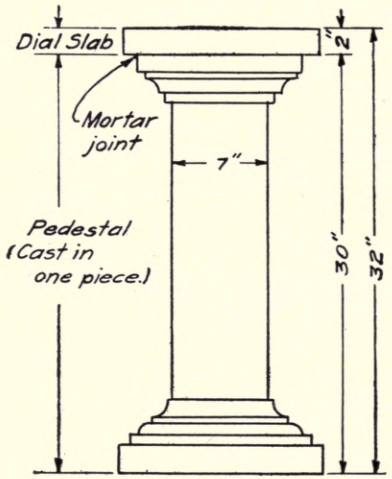


PLATE 18

of three segments *a* turned to the desired shape in a lathe. Cap is made of three segments *b* also turned to the desired shape. Top piece *c* may be made of one piece with hole in the center for tenon. This hole should be slightly tapered so that *c* may

be withdrawn easily. It should not be fastened to *b* because it must be lifted off the casting or object before other forms are removed. The forms should be filled up to the top of *b*, then piece *c* is put on and weighted down and filled with concrete to the top.

Plate 19 shows a pedestal for sundial. This is the same as that shown in Plate 18. The dial slab is cast separately and



Elevation of Sun Dial.

PLATE 19

attached to the pedestal by cement mortar. In using the preceding designs for building this pedestal the mortise and tenon should be omitted.

Plate 20 shows design for a concrete bird bath or fountain. The same pedestal is used as for the two preceding objects. The core consists of one piece *b*. The basin or bowl is cast bottom side up. The core should have a slight draft at edge *a* to make

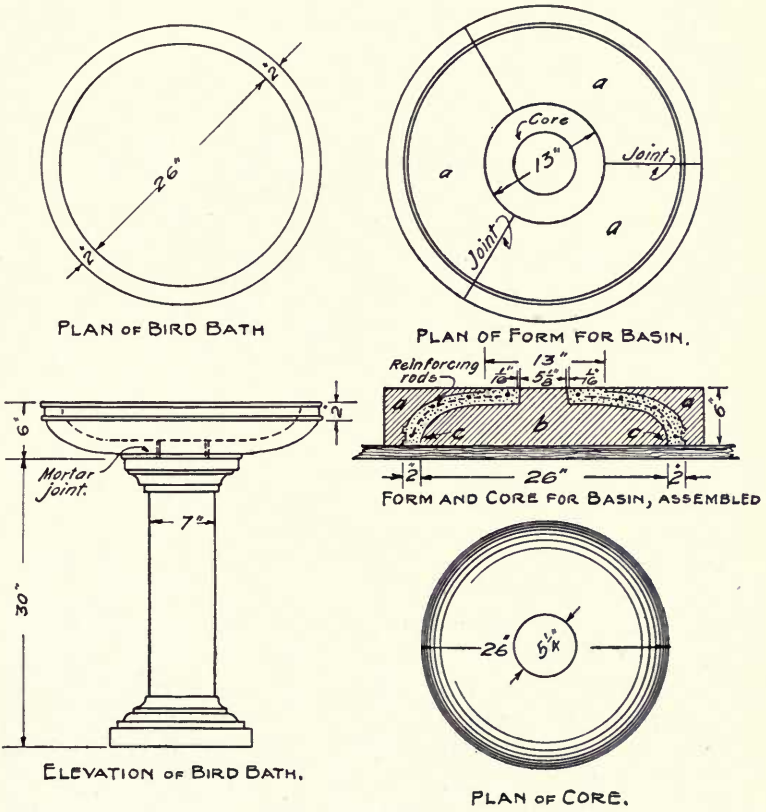
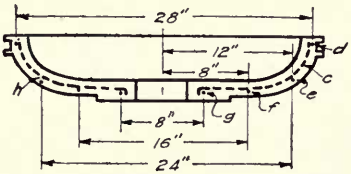
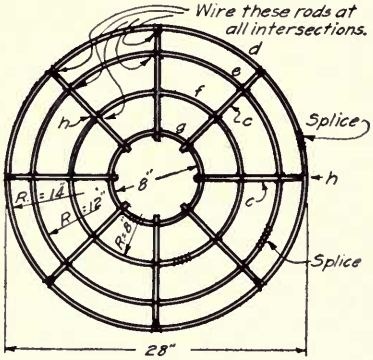


PLATE 20

withdrawal easy. Reinforcement consists of rings of light rods wired to radial rods as shown in the lower portion of Plate 21, or expanded metal or wire mesh fabric may be cut and developed to form the reinforcing required.



Section through Basin showing reinforcement.



Plan of Reinforcing Rods assembled.

PLATE 21

An elaborate entranceway of concrete. The columns carry artistic receptacles for electric lights.

Plate 22 shows various details of a garden fountain. The pedestal is the same as that illustrated in plates immediately preceding except that the tenon is 7/8 inch high. The basin of the fountain is identical with that illustrated in Plate 20. The nozzle of the fountain is built up of pieces *a*, *b*, *c*, *d*, *e*, and *f* as shown in the upper right-hand sketch of Plate 22. Part *d* is turned out in a lathe and nailed to parts *c*, *b*, and *a*. Part *f* is nailed to *d*

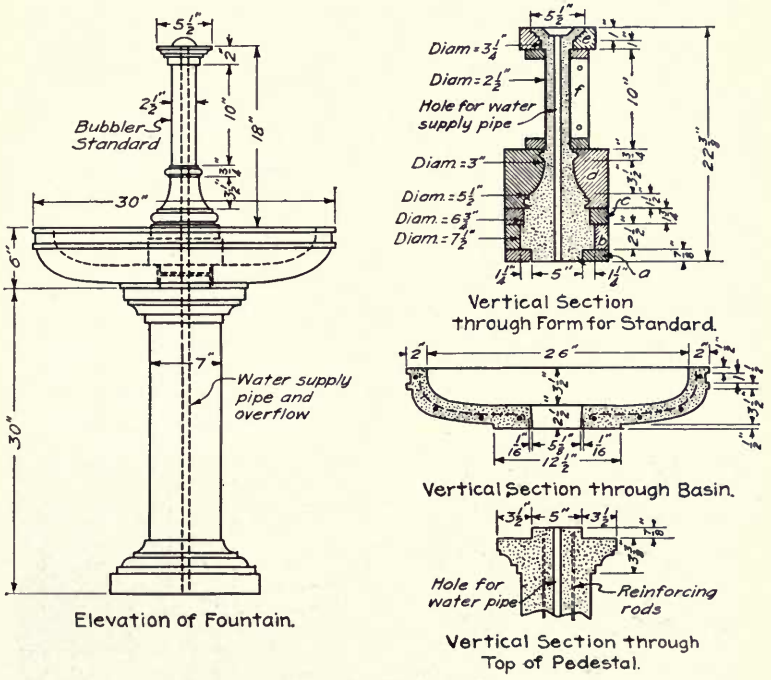


PLATE 22

and *e*. This form is made in three segments as previously described. Suitable arrangements must be made for water pipe and overflow. The nozzle spray is of metal and is fitted in the top of the nozzle pipe. The pedestal, basin, and bubbler standard are connected as shown in the illustration at the left-hand portion of Plate 22.

Plate 23 illustrates a cylindrical form similar to that shown in Plate 17. This is to be used for a plain cylindrical flower pot which is cast bottom side up. The core is the same as that described in connection with Plate 6 except that it is square instead of cylindrical. The top and bottom sections of the form should be marked with figures 1, 2, 3, and 4. Part 3 shown in the sketch illustrating a section through the core at *B-B* is withdrawn first. Then part 1 is taken out. Pieces 2 and 4 can then readily be removed.

Concrete roads like this may cost a little more than some other kinds in the beginning, but they are cheaper in the end than any other road. There are thousands of miles like this in the United States.

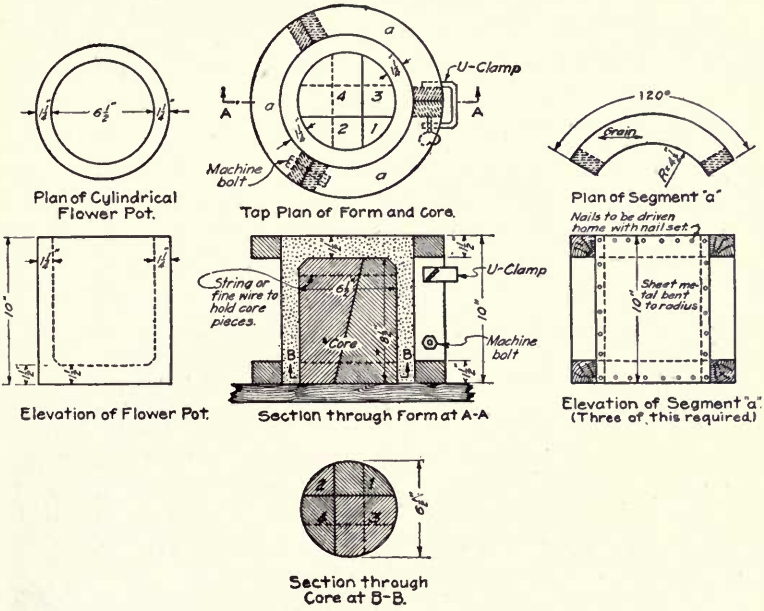
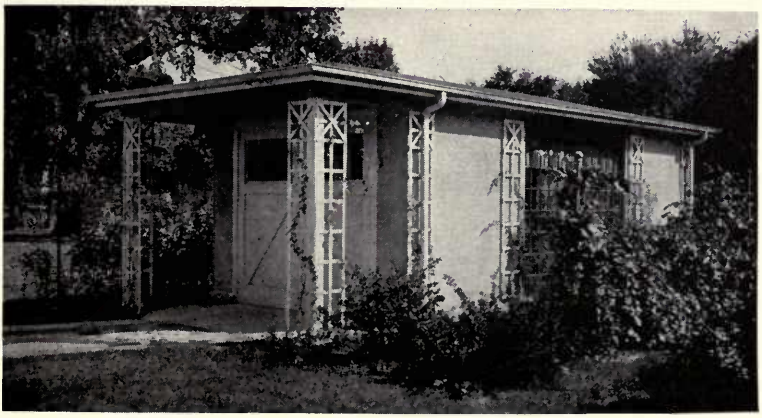

Plan of Cylindrical Flower Pot.
Top Plan of Form and Core.
U-Clamp
Machine bolt
Plan of Segment "a"
120°
Grain
Nails to be driven home with nail set
Elevation of Flower Pot.
String or fine wire to hold core pieces.
Core
Section through Form at A-A
Sheet metal bent to radius
Elevation of Segment "a". (Three of this required.)
Section through Core at B-B.

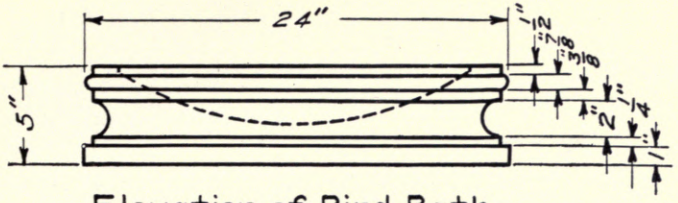
PLATE 23



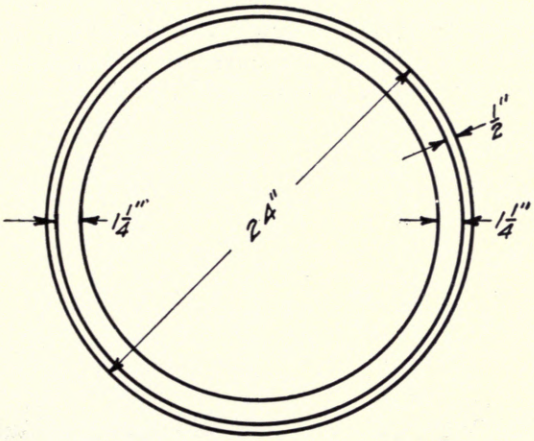
Every automobile should be kept in a firesafe garage. This one is concrete.

Plate 24 shows details of forms for bird bath. This is built up of the three pieces *a, b,* and *c,* which are turned in a lathe to obtain the required exterior shape for the bath. They are then nailed together and the resulting ring is cut into three segments that are held together by blocks *d,* which are nailed to the workbench. The core is made in one piece. It is held in position on the workbench by dowel pins *e.* The bath is cast bottom side up. When concrete has been brought to within 1 inch of the surface, light wire mesh or expanded metal reinforcement may be pressed into the concrete and the remainder of the concrete placed. Ordinarily reinforcement will be required only for basins or bowls of large diameter.

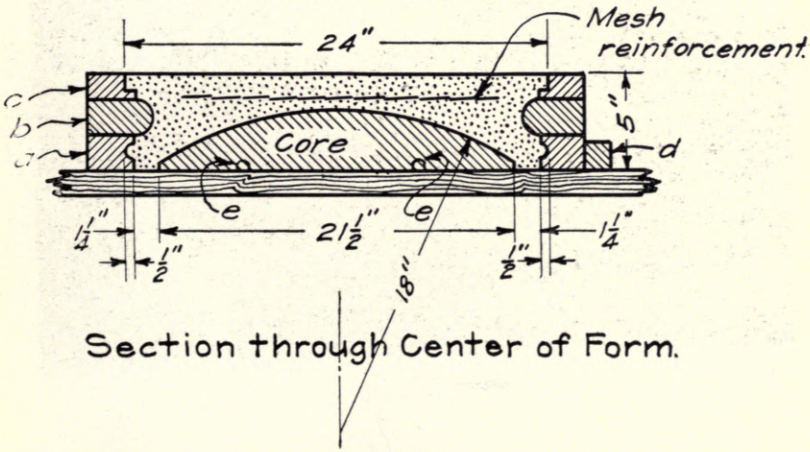
Concrete block used to make a permanent and attractive wall to enclose the home grounds.



Elevation of Bird Bath.

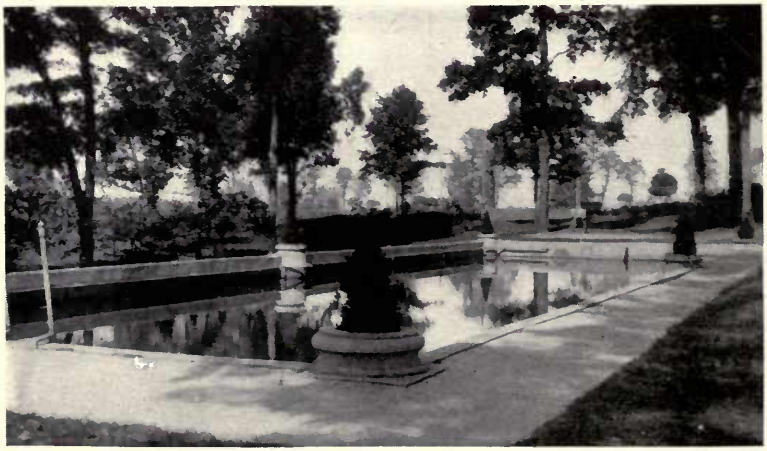


Plan of Bird Bath.



Section through Center of Form.

Plate 25 shows details of a form for building a combined basin and pedestal. Pedestal and basin are cast separately. Form for the pedestal is composed of the pieces *a, b, c, d, e, f, g,* and *j*. Pieces *b* and *g* may be of stock molding. Ornament *h* is formed by carving or cutting out the inner face of piece *d*. When the component parts of the exterior form are properly assembled by nailing or screwing together, mitered joint is made. The core is built as shown in Plate 2. Outer corner may be beveled or rounded. Pedestal may be cast right side up or vice versa. Forms are held in position and properly assembled by means of clamps, metal bands, or other devices as previously described.



Concrete swimming pools can be very plain and simple, or quite elaborate.

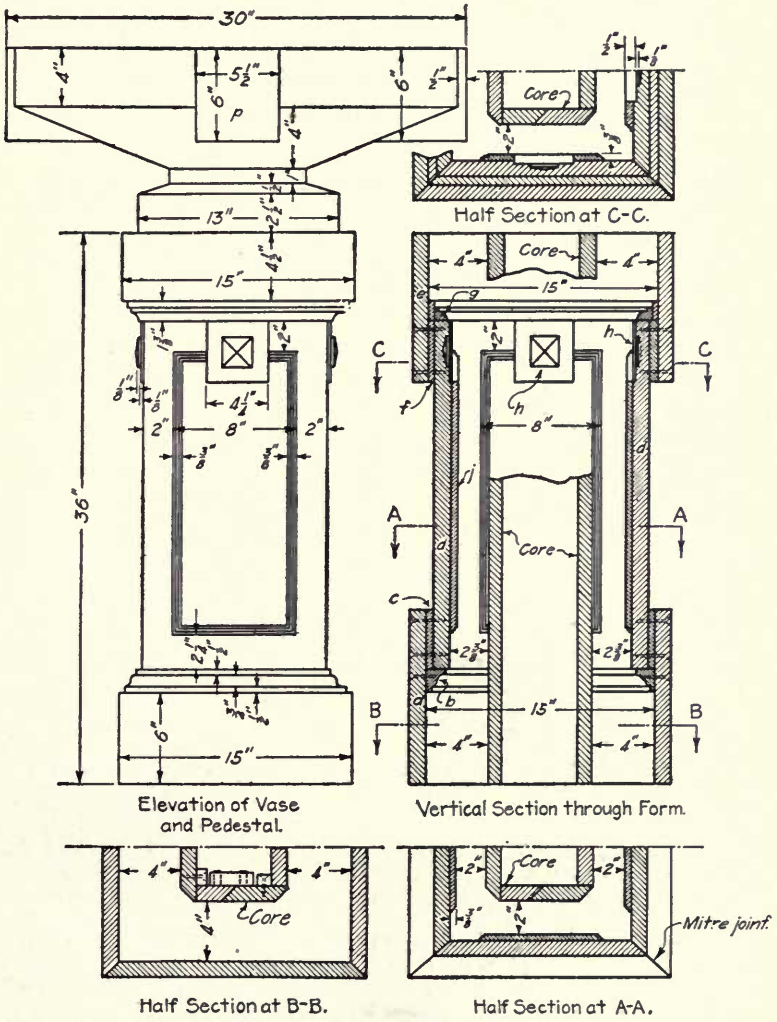
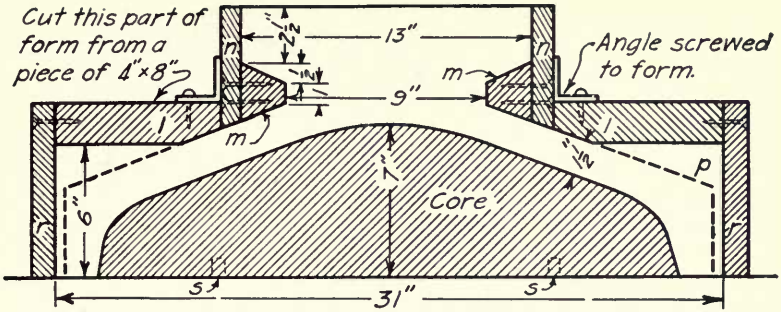

30"
4"
5½"
6"
6"
p
4"
13"
15"
36"
6"
15"
2"
8"
2"
4½"
Core
Half Section at C-C.
Core
4"
4"
15"
C
C
8"
A
A
Core
B
B
15"
4"
4"
Elevation of Vase and Pedestal.
Vertical Section through Form.
4"
4"
Core
Half Section at B-B.
Core
Mitre joint.
Half Section at A-A.

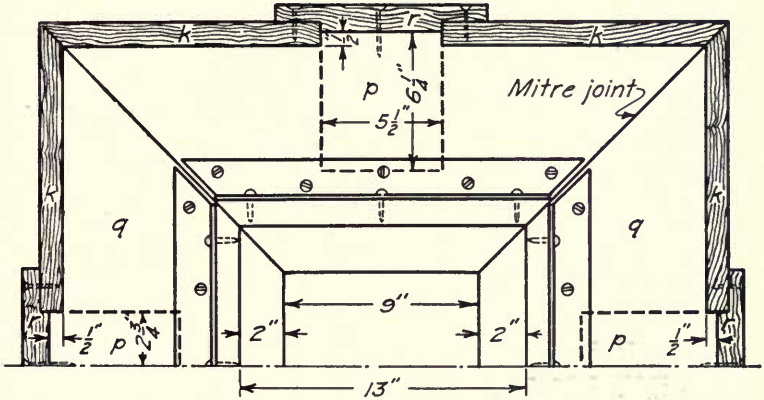
PLATE 25

Plate 26 shows details of form for a vase. This consists of parts *k, l, m, n,* and *q* nailed together after the surfaces of parts *l, m,* and *n* have been properly shaped or fashioned. Parts *l* and *m* are made rigid so as to withstand frequent handling of forms by screwing pieces of angle iron to them as shown. These parts having been properly assembled, mitered joint is made. Ornament *p* is formed by cutting out parts of pieces *q* and *k* and nailing to *k* the piece marked *r*. Core is made in one piece and held in position by dowel pins *s* set up on workbench. Reinforcing for the vase is placed as shown in Plate 43. For ordinary conditions the pedestal will require no reinforcement.

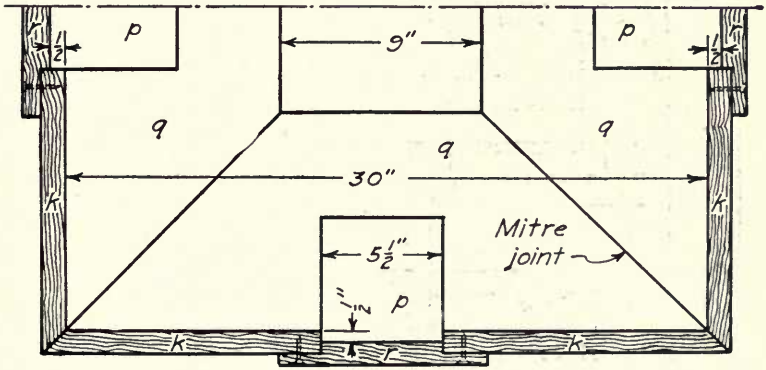
On many farms stock are fed on concrete feeding floors, which can readily be kept clean, and prevent waste of grain.



Vertical Section through Vase Form.

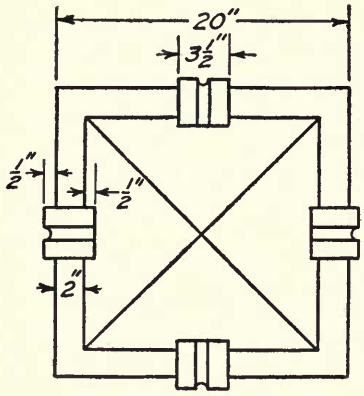


Half Top View of Vase Form.
(Vase cast upside down.)

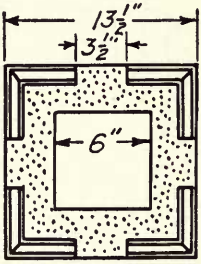


Half Inverted Plan of Form.

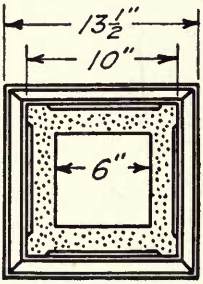
PLATE 26



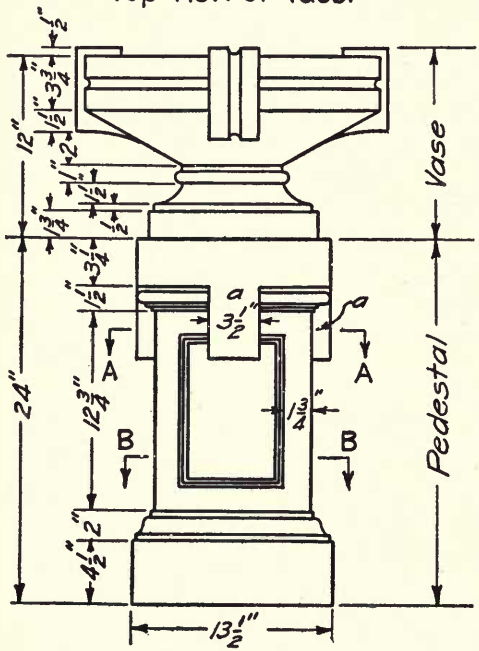
Top View of Vase.



Section at A-A.

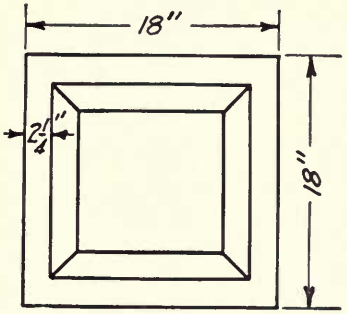


Section at B-B.

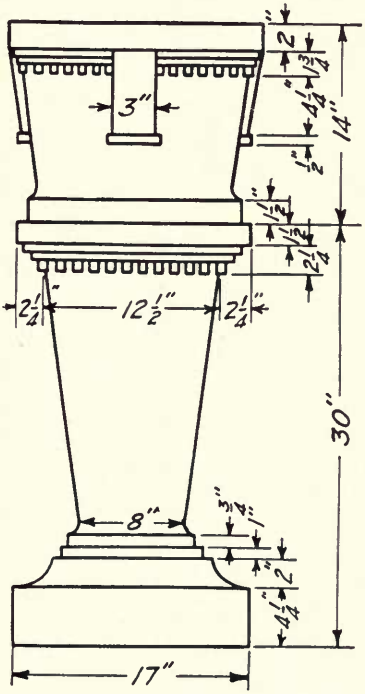


Elevation of Pedestal and Vase.

PLATE 27



Top View of Vase.



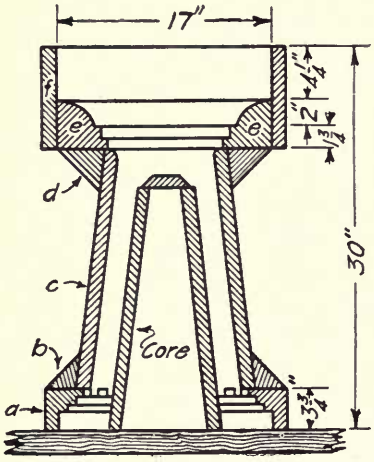
Elevation of Vase and Pedestal.

PLATE 28

Plate 27 offers additional suggestions for combined vase and pedestal. The form for the pedestal is the same as that described in the preceding plate with the exception of ornament *a* which, however, is formed in a manner very similar to that used in forming ornament *p* on Plate 26. In other respects the vase is similar except for the variations in ornamentation.

Plate 28 is merely an elaboration of preceding designs.

Plate 29 shows forms for combined pedestal and vase. The various parts are *a, b, c, d, e,* and *f*. Part *a* can be made of one piece as shown or may be built up from 4 pieces of thin stuff nailed together to form a molding. Part *e* may be formed of one piece or likewise built up, two pieces of board and a piece of ¼-inch round molding being then used. Mitered joints are made after parts *a, b, c, d,* and *e* have been assembled with screws. Parts *b* and *d* are braces and may be made either as shown or of angle iron. The pedestal is cast bottom side up. It may be used without a vase as a flower urn or with a plate on top may serve as a sundial and pedestal.

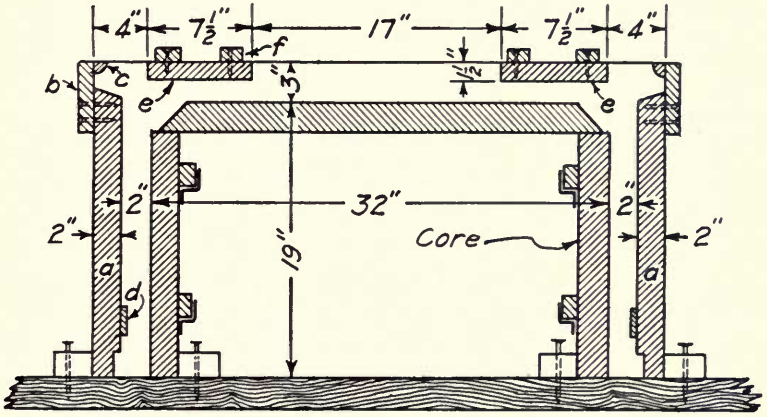


Section through Center of Form for Pedestal.

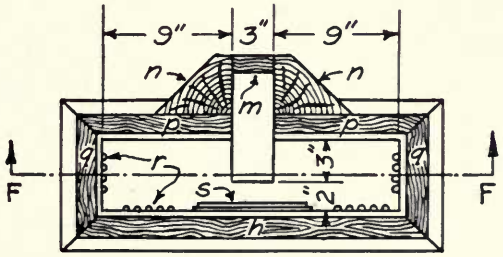
PLATE 29

A concrete well curb and platform goes a long way to prevent surface filth from getting into the home water supply.

Plate 30 shows details of a design for flower box. The exterior form consists of parts *a*, *b*, *c*, and *d*. Part *a* is beveled at the upper end and rabbeted at the lower end. This rabbet forms a cornice around the top of the finished object. Part *c* consists of a piece of ¼-inch round attached to the part *b*. Part *d* consists of thin narrow strips of wood attached to part *a* so that they form a Greek key. These strips should be tacked on



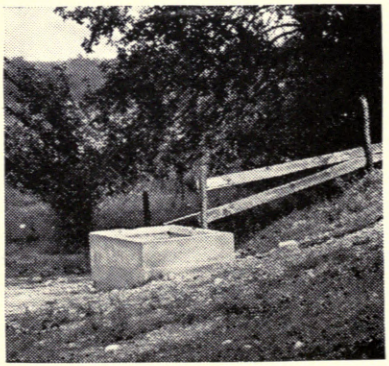
Section through center of Flower Box Form.



Plan of Form with Top removed.

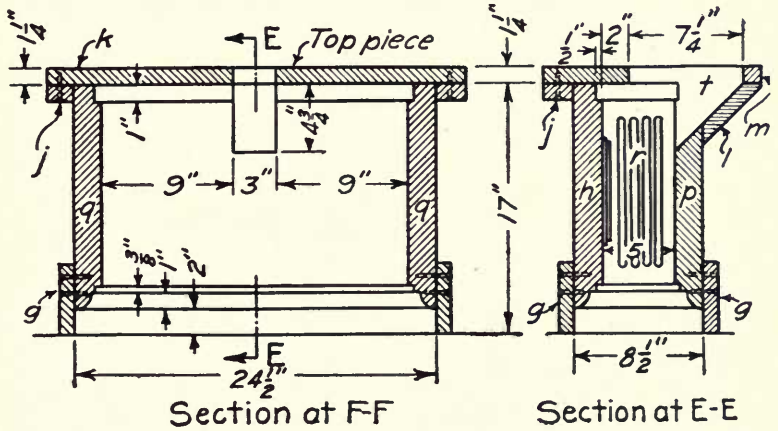
PLATE 30

with small brads to prevent splitting and also to prevent defacing the exposed surface. All edges of these strips should have a slight draft to make form removal easy. The box is cast bottom side up. Mortises formed in the bottom of the concrete box are made by part *e* which is held in place in the form by means of cleat *f* extending to the sides. The core is of a pattern previously described. Reinforcement may be wire mesh or expanded metal. Care should be taken that mortises are placed in the exact position shown.



This concrete spring casing serves also as a stock drinking trough in the pasture lot.

Plate 31 gives details of legs or standards for supporting the box shown in Plate 30. These forms consist of parts *g*, *h*, *j*, *k*, *l*, *m*, *n*, *p*, *q*, *r*, and *s*. The bottom edges of parts *h* and *p* are shaped by the worker and the top rabbeted as shown. Part *h* has piece *s* and small strips *r* attached to the inner face so as to form ornament. Parts *q* have strips *r* attached to mold the fluting. Part *p* is cut out at the top at the center to form a bracket on inner side. The form for this bracket consists of pieces *m*, *n*,



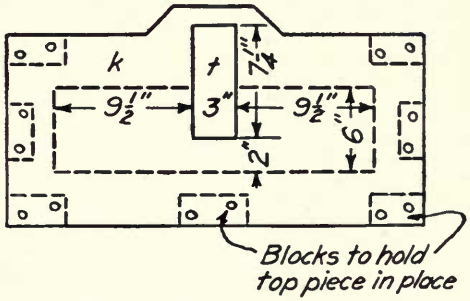


PLATE 31

and *l*. The bottom sides of pieces *n* are cut to the bevel shown and piece *l* is nailed to the beveled surface of two pieces forming the bottom of the bracket. Piece *m* is nailed between the two pieces *n*. The side faces of the bracket form should be given slight draft to make withdrawal easy. Top piece *k* is placed on top of form after concrete has been brought up to surface. The opening *t* is then filled with concrete. Care should be taken to have this opening in a position corresponding with mortise in the bottom of the box.

The details of assembling this box on its supports are shown in Plate 32.

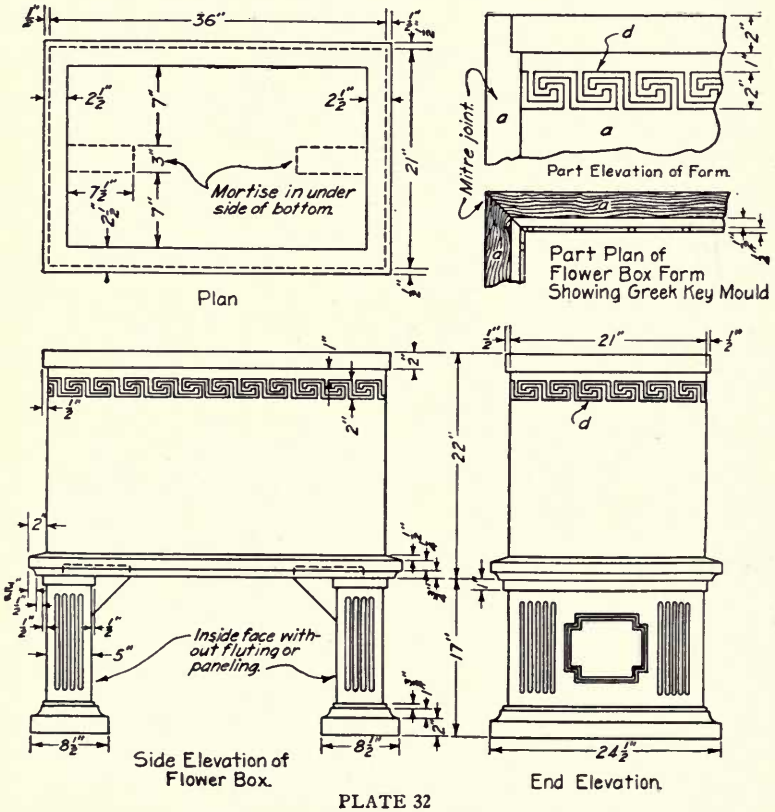


PLATE 32

Plate 33 shows details for a garden bench. The form for the seat slab consists of part *a*. This has mitered joints and as assembled is held in position on the workbench by small blocks. Part *a* when made of the shape shown should always terminate in a small member *c*. If the curve is brought down to a feather edge the concrete soon slivers off. Mortises are formed by holding part *d* in position shown by means of cleats *e* extending across the top of form.

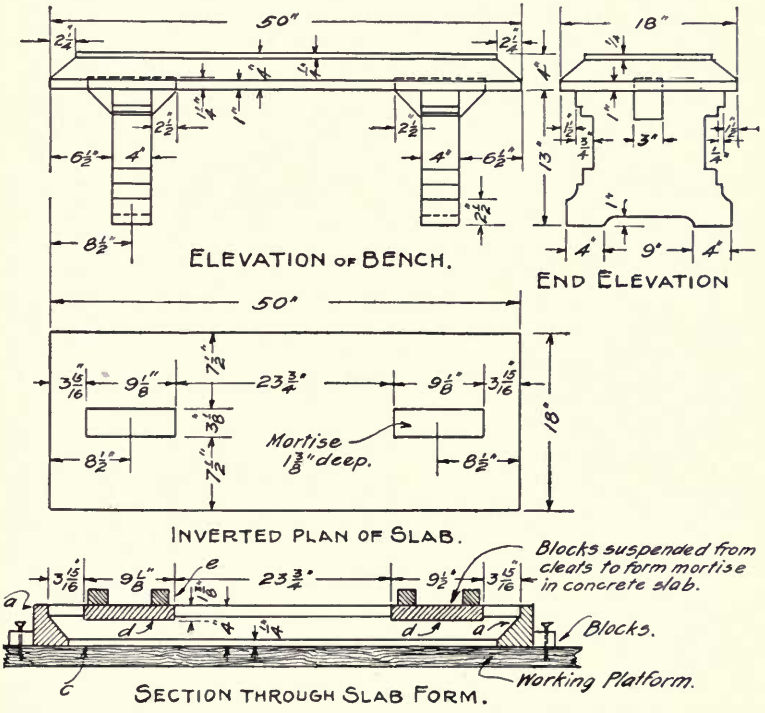


PLATE 33

Plate 33A shows forms for the legs of the bench illustrated in Plate 33. These consist of pieces *f*, *g*, *h*, *j*, *k*, *l*, and *m*. Piece *f* is cut out from one piece by a band saw and the surface smoothed with sand paper. Brackets are formed by nailing parts *h* to the sides. Sides are cut out at the top for a bracket. Part *j* is nailed to parts *h*. Part *t* is nailed to the workbench in proper position, the legs right side up. Concrete is placed in the form to the top after which piece *k* is set in place and opening *l* filled with concrete. Care should be taken to have tenon *l* and mortise *d*, shown in Plate 33, in proper relative position.

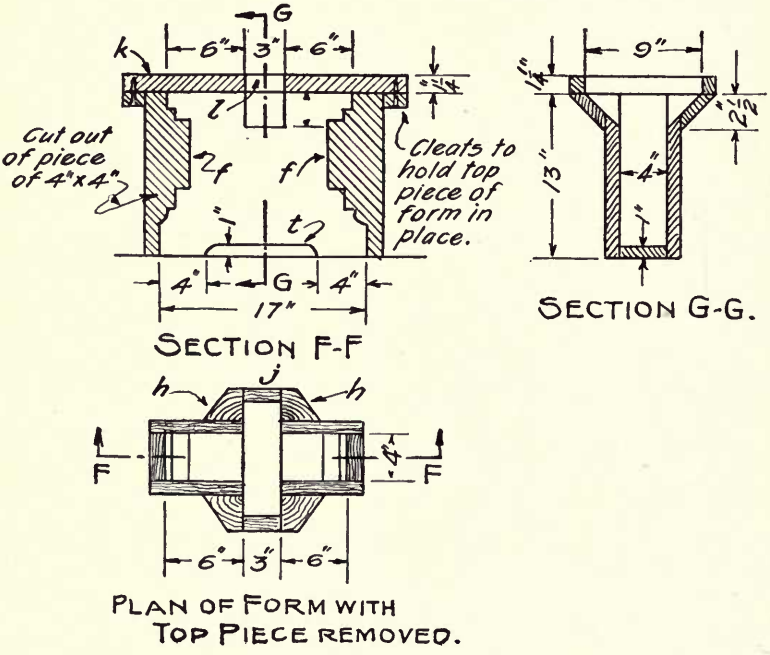


PLATE 33A

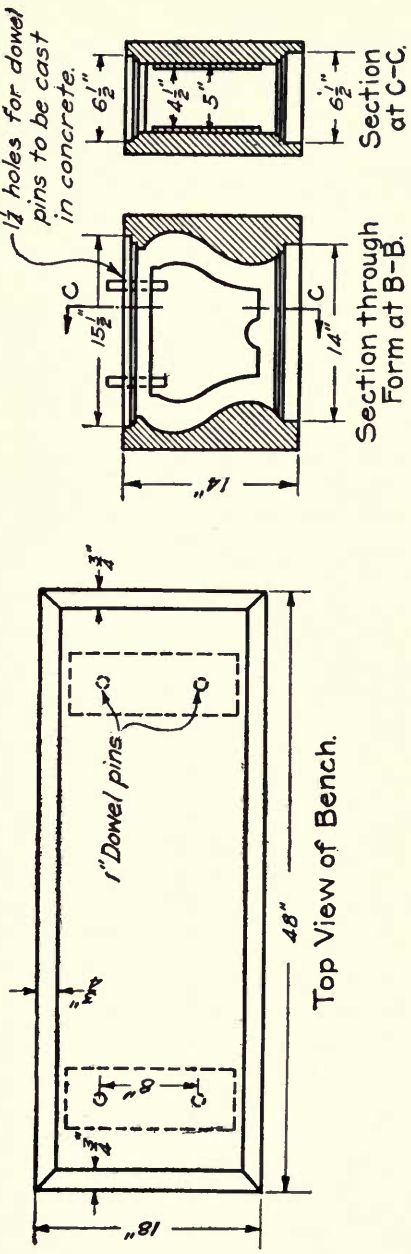
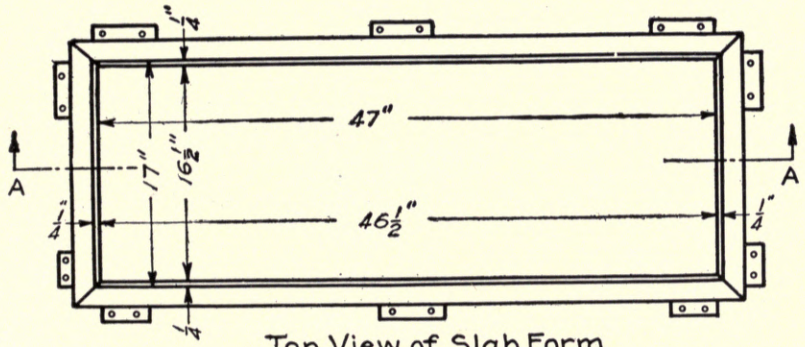
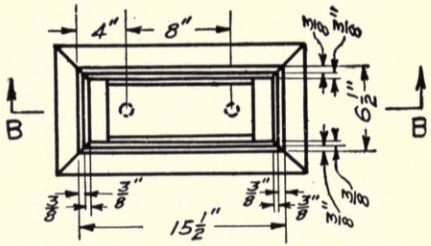


PLATE 34

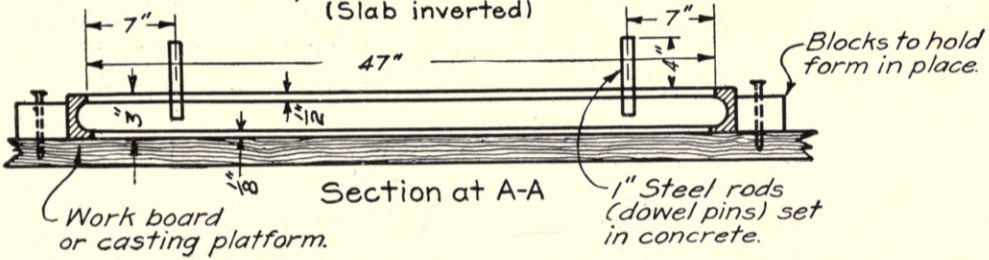
Plates 34, 35, and 36 contain further suggestions for a more ornamental garden seat. Forms in general are like those shown in Plates 33 and 34. Instead of using brackets on legs, dowel pins and a mortise joint are used for assembling legs and seat slab. The legs are cast right side up. A greased rod is suspended in the form in proper position to make hole in the concrete for dowel pin. Corresponding holes are formed in the bottom of the seat slab. In assembling the bench the dowel pins are first set in the bottom of the slab while it is still bottom side up and secured in place by a cement grout. When this has hardened, holes in the top of the legs are filled with grout and covered with a bed of mortar. The slab is then placed in position. The dowel pins enter the grout filled holes and are thus firmly held.



Top View of Slab Form
(Slab inverted)



Top View of Form



Section at A-A

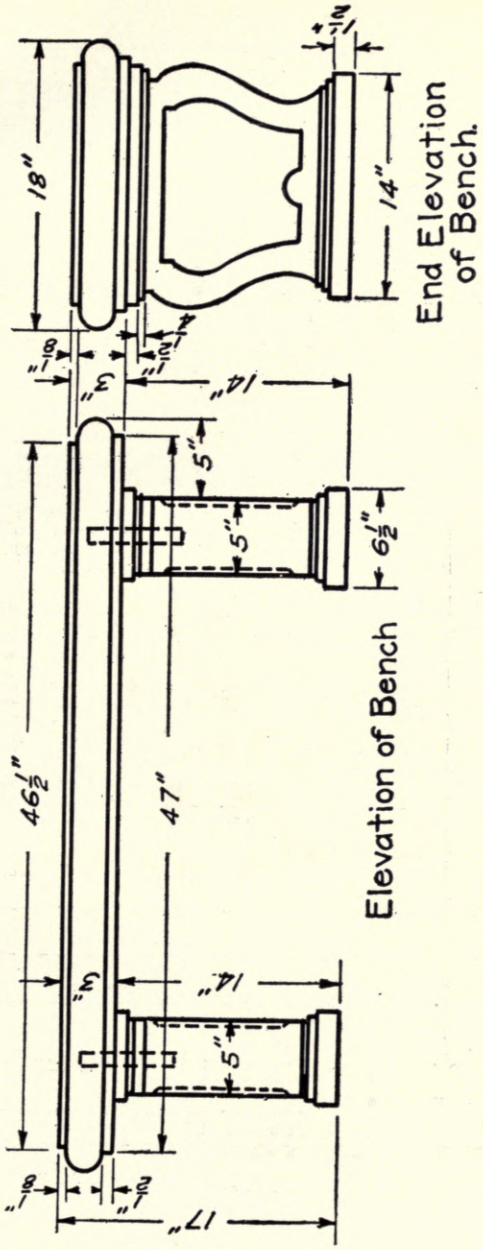

End Elevation of Bench.
18"
14"
1½"
¾"
⅛"
1"
3"
14"
5"
5"
6½"
Elevation of Bench
46½"
47"
3"
14"
5"
⅛"
1"
17"

PLATE 36

A still more elaborate garden seat is shown in Plates 37, 38 and 39. A front elevation and sectional plan of the completed product is shown on Plate 37. The seat is made in four parts—the back, the two end columns and the seat slab. An ornamental vase or flower pot may be placed at the top of the columns as shown in elevation, if desired. The back and center leg are cast in one piece, the form for this being shown in detail in Plate 38.

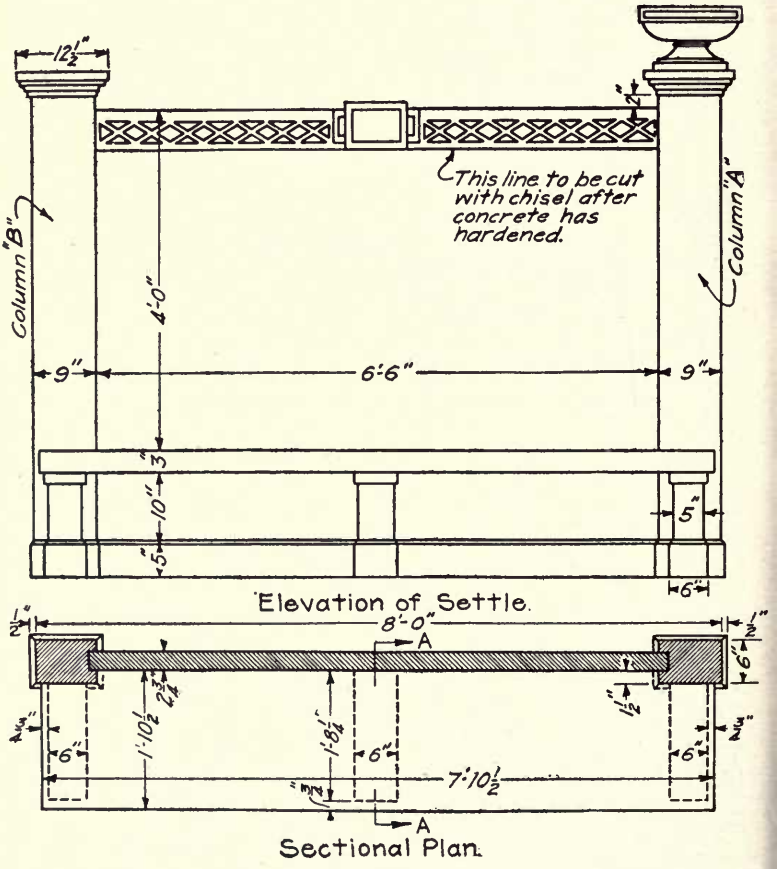
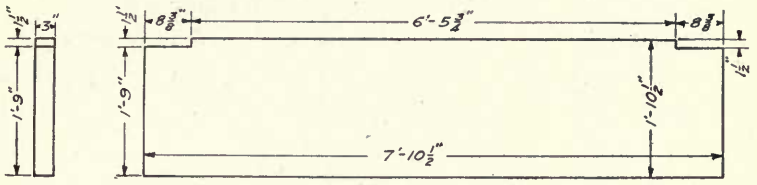
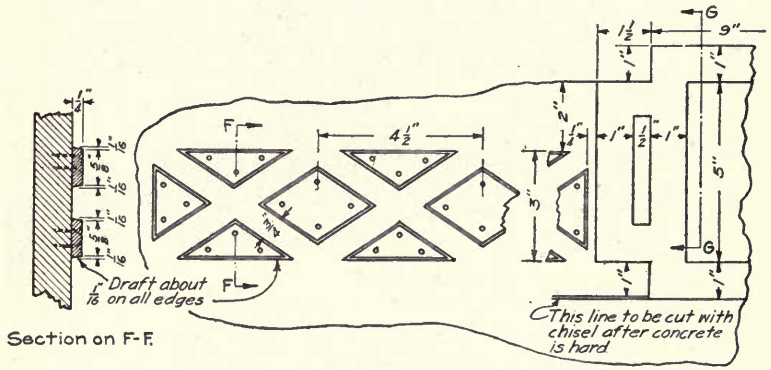


PLATE 37


1'-9"
End Elevation.
6'-5¾"
7'-10½"
1'-10½"
Plan of Seat


F
4½"
Draft about 1/16 on all edges
Section on F-F.
G
9"
This line to be cut with chisel after concrete is hard
Detail of Ornament.

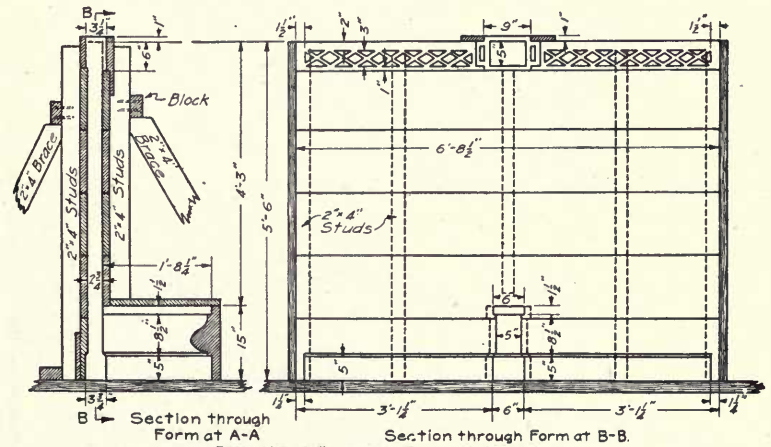

Block
Brace
2"x4" Studs
6'-8½"
4'-3"
5'-6"
15"
3'-1½"
6"
Section through Form at A-A
Section through Form at B-B.
Details of Form for Back of Settle.

PLATE 38

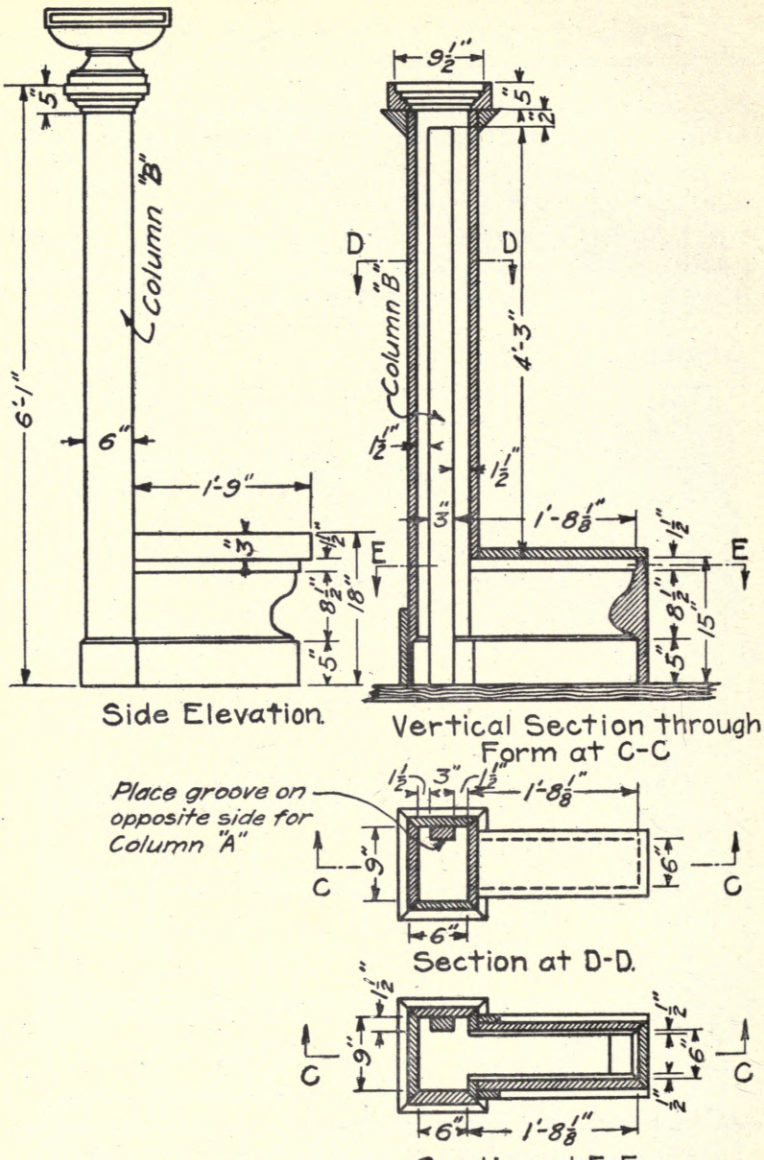
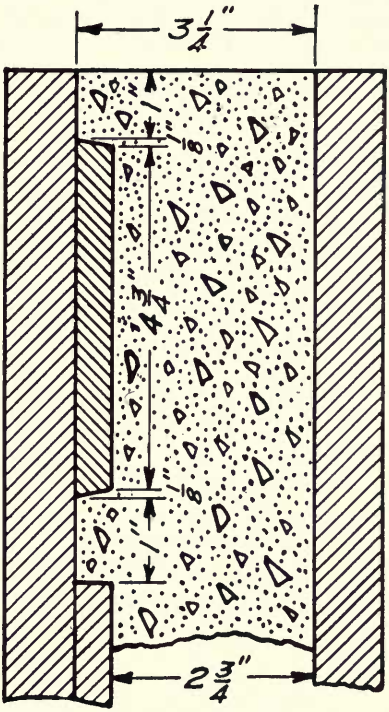

Column "B"
6'-1"
6"
1'-9"
3"
1½"
8½"
18"
5"
E
Side Elevation.
9½"
5"
2"
D
D
Column "B"
4'-3"
1½"
1½"
3"
1'-8⅛"
1½"
8½"
15"
5"
E
Vertical Section through Form at C-C
Place groove on opposite side for Column "A"
1½"
3"
1½"
1'-8⅛"
9"
6"
C
C
6"
Section at D-D.
1½"
9"
1½"
1½"
9"
1½"
C
C
6"
1'-8⅛"
Section at E-E.
Details of Form for Column "B"

PLATE 39

The form should be built so that the concrete may be placed into it from the top and should be clamped or screwed together in such a manner that the forms for the center leg may be removed first. Care should be taken to have the joints of the forms water-tight. In work of this nature it is best to have tongued and



Section on G-G.

PLATE 40

grooved boards for the large flat surfaces. The forms for the ornamental work at the top of the seat back are shown in detail in Plates 38 and 39. The back must be reinforced with heavy expanded metal or with ¼-inch bars spaced about 8 inches on

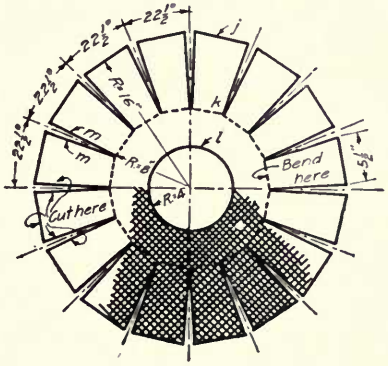
centers in both directions. The expanded metal or bars should also extend into the center leg and be securely fastened to the reinforcement in the back.

The seat is a simple concrete slab reinforced with heavy expanded metal or ¼-inch bars placed 4 inches on centers longitudinally. The reinforcement for both the back and the seat should be placed about in the middle of the slab. If desired, the seat may be cemented to the back and legs. The forms for the columns A and B are shown in Plate 39. They are made in a manner similar to forms for pedestals and columns heretofore described. The groove indicated on the drawing should be true and slightly larger than the thickness of the back slab. When the back and columns are assembled, cement grout should be poured into these grooves in order to cement these parts together. All faces of the concrete work should be rubbed down with carborundum brick and water in order to secure a uniform surface and to remove all signs of form joints. At very little additional expense a beautiful surface may be obtained by using white portland cement and granite or marble screenings which, when rubbed down and polished, gives the appearance of solid granite or marble.

The forms required for this work are only an elaboration of the ones heretofore described for various products, and by carefully following the drawings and using a little ingenuity, they can be built economically and may be used a number of times.

SHAPING REINFORCEMENT

Instead of using steel rods or wires for reinforcement as shown on Plate 21, page 122, for bowls or basins such as in fountains, expanded metal or wire mesh may be used, and in many cases will be preferable. Whenever expanded metal or wire mesh is used for such purposes, it will be necessary to cut the flat sheets so that the reinforcement when bent up will conform to the lines of the product. This is called developing the sheet of reinforcement. For example, in order

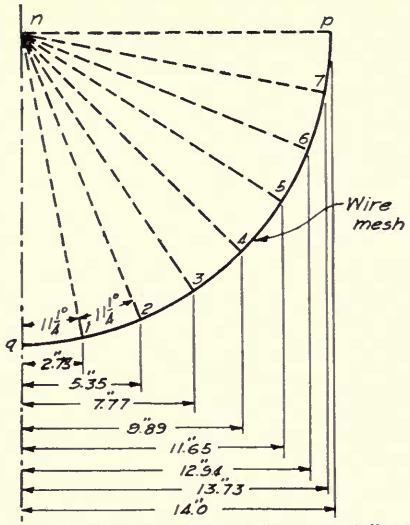


Developed Sheet of Wire Mesh reinforcement for Basin.

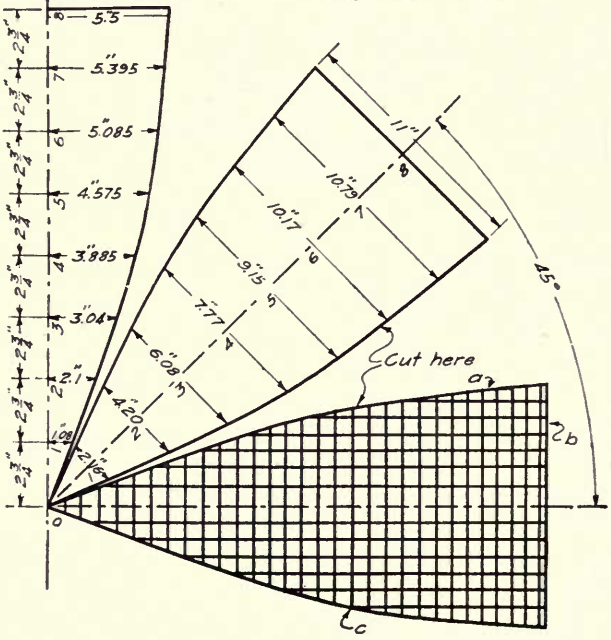
PLATE 41

to have the reinforcement for the basin of the fountain shown on Plate 21 conform to the shape of the basin, it will be necessary to cut the flat sheet as shown in Plate 41. After the necessary cuts have been made, the sheet should be bent along the dotted lines as shown and the laps securely wired with black stove wire. If the bowl is larger in diameter than the one shown, a greater number of radial cuts may be required.

When the bowl is flat, such as the one referred to, these radial cuts may be made as shown, but if the bowl is hemispherical it will be necessary to cut the sheet as shown in



Half Vertical Section through Wire Mesh.



Developed sheet of Wire Mesh reinforcement.
(Reinforcement for Hemispherical Bowl.)

PLATE 42

Plate 42. This illustration shows a convenient method for laying out such developed sheets. In this case the flat sheet is composed of eight equal sectors, two and one-half of which are shown in plan. When these sectors are bent up so that their edges meet, they will form a hemisphere. The length of the flat sector along the center line is equal to the length of the arc of a circle shown in the upper part of the drawing. In this example it was found convenient to divide the

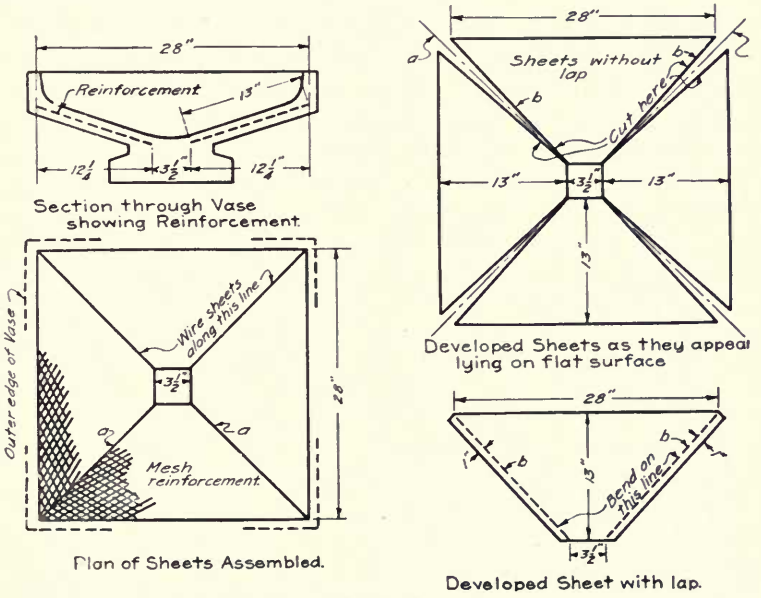


PLATE 43

sector into eight equal parts, each 2¾ inches long. The 90° vertical arc is also divided into eight equal parts, the length of each part measured on the circumference being equal to 2¾ inches. The dimension at the outer edge of the flat sector, 11 inches, is equal to one-eighth of the circumference at the outer edge of the reinforcement at *p* when the sectors are bent into the form of a hemisphere. The dimen-

sion 10.79 inches is equal to one-eighth of the circumference at the point (7) in the half vertical section through the wire mesh with a radius of 13.73 inches. The dimension 10.17 inches is equal to one-eighth of the circumference at (6) when the radius is 12.94 inches. Each successive dimension toward the center of a sheet at (0) is equal to one-eighth of the circumference at its respective point shown in the half vertical section. The developed sheets for hemispherical bowls of any diameter may be laid out in a similar manner. A practical illustration of developing these sheets may be had by cutting an orange in two equal parts and slicing the peel into eight equal parts from the circumference of the orange to the bottom and laying the eight sectors thus formed flat on a table. The shape of the orange peel sectors will be almost identical with the sectors shown in plan on Plate 42.

The developed sheet for square bowls is shown in Plate 43.

It is important to securely wire all edges of developed sheets in order to secure the necessary strength required from the reinforcement, that is, to make the reinforcement truly continuous.

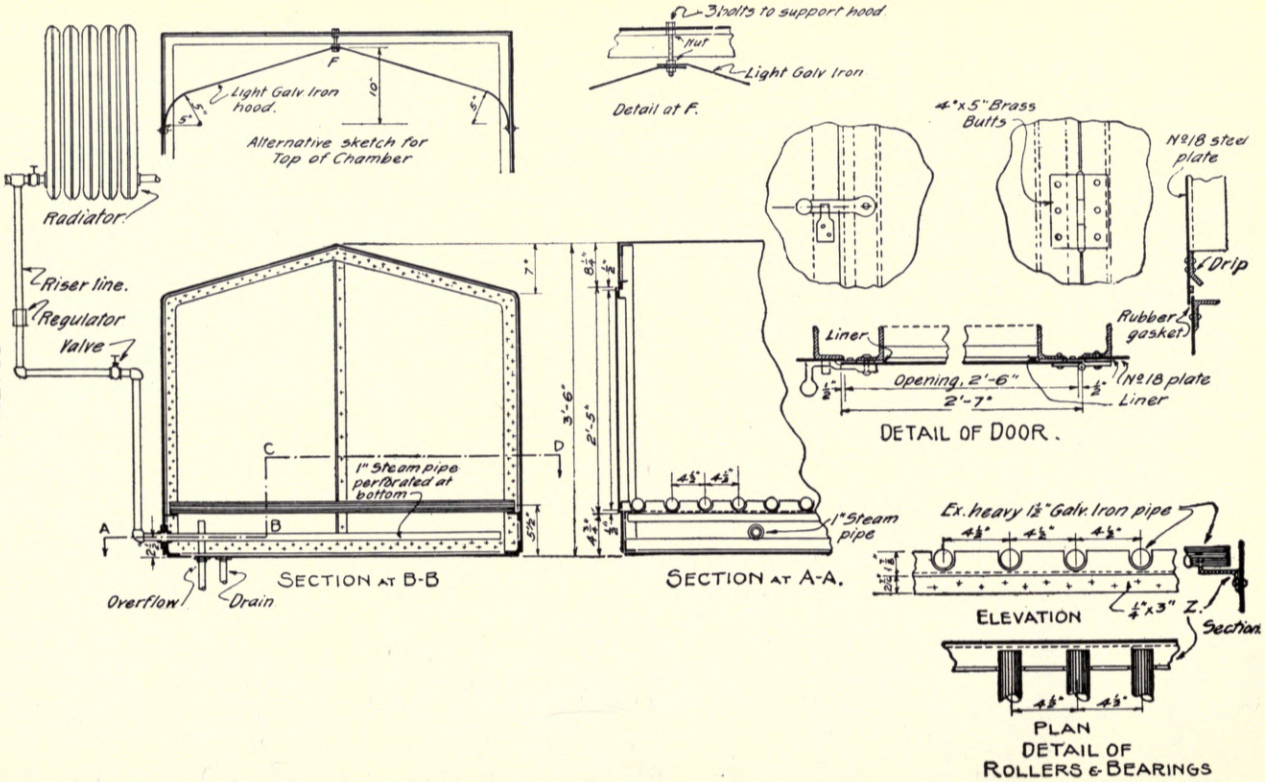
One way of ornamenting concrete is to inlay colored tile in the surface. This gateway with flower boxes shows the artistic possibilities of concrete.

STEAM HARDENING, OR "CURING," CONCRETE PRODUCTS

General.—In the commercial manufacture of concrete block, brick, tile, fence posts, and other small concrete products, it is best to arrange for hardening the products in steam rooms. These rooms are called "curing chambers," and the process of hardening in this way is commonly known as steam curing. However, the word "curing" as used in this sense should not be taken to mean a drying action as the effect of hardening or curing concrete products in steam rooms is exactly the reverse of drying, that is, the products are kept in a warm, vapor-laden air which not only hardens them more rapidly, but more uniformly, as a combination of warmth and moisture produces the most favorable conditions for uniform hardening of concrete.

For home work it is not usually practicable to arrange to harden concrete products by using steam, but for school work it is possible to build a small chamber for steam hardening many small ornamental products which can thus be given an important finishing touch of concrete workmanship.

Design for Small Portable Steam Curing Chamber.—Accompanying sketches, Plates 44 and 45, show details of a small portable steam curing chamber that can readily be attached to any source of low pressure steam supply, even to a steam heating system such as used in the ordinary residence. The chamber consists of a steam-tight box, 3 by 4 feet in plan and 3 feet 6 inches deep. The roof must be sloped so condensation will drain toward the sides and not fall directly on the concrete, thus pitting it while soft. The chamber is built of steel framing covered with sheet steel. The frame consists of two 2-inch by 2-inch angle irons. These are joined where necessary by rivets. After the frame has been assembled, the metal covering, which consists of No. 18 gage steel plate, is riveted to the framework. Rivets should be set close enough together so that when tightened, all joints


3 bolts to support hood
nut
Light Galv Iron
Detail at F.
Light Galv Iron hood.
Alternative sketch for Top of Chamber
Radiator
Riser line.
Regulator Valve
4"x5" Brass Butts
No 18 steel plate
Drip
Rubber gasket
Liner
Opening, 2'-6"
2'-7"
No 18 plate
Liner
DETAIL OF DOOR.
1" Steam pipe perforated at bottom
1" Steam pipe
SECTION AT B-B
SECTION AT A-A.
Overflow
Drain
Ex. heavy 1½" Galv. Iron pipe
4½"
4½"
4½"
4"x3" Z. Section
ELEVATION
PLAN
DETAIL OF ROLLERS & BEARINGS

formed will be steam-tight without calking. Two Z-bars ¼ by 3 inches are cut out, as shown in one of the detailed sketches, to receive rollers and bearings. These rollers are to make it easy to slide a platform bearing the objects into the chamber or even to slide the objects themselves in while resting upon the rollers. These Z-bars are riveted to the steel plate sides of the chamber so that the bearings of the rollers will be 5½ inches above the bottom of the chamber, as shown.

The door to the chamber is made of No. 18 gage steel plate riveted to 2-inch by 2-inch angles and provided with a liner as shown. The door opening is reinforced with the same size of angles at the sides, top and bottom. At the bot-

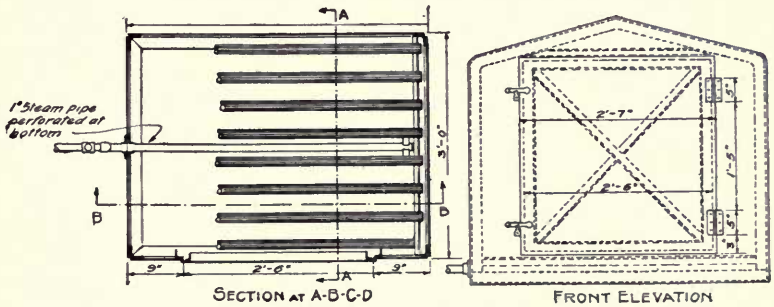


PLATE 45

tom of the door there is a bent strip of No. 18 gage steel plate attached to serve as a drip to catch and properly dispose of the water condensed from the steam. The door is attached to the chamber by two 4 by 5-inch brass hinges which are riveted to the door and to the door frame.

To make the door opening practically steam-tight, a rubber gasket is attached to the inner face of the outside edge of the door. Latches are attached to the door as shown. The bottom of the chamber is fitted with flanges for overflow and drain pipes as shown in section B-B.

A 1-inch steam pipe fitted to flanges runs longitudinally across the bottom of the chamber, as shown in section B-B and section ABCD. The lower side of this pipe is perforated at intervals of 1½ to 2 inches by small holes to permit entrance of steam from the source of supply. As shown in Plate 44, the outer end of this pipe is connected with a steam radiator.

The riser line should be provided with a regulator and shut-off valve, the regulator being placed between the valve and the radiator. The overflow pipe should be about 4½ inches above the bottom of the chamber, thus assuring from 4 to 4½ inches of water will remain in the chamber so that the steam can issue through this water and thus be completely saturated. Dry steam, that is, steam under pressure, must never be admitted direct to a chamber of this kind, as it would dry the products rather than harden them.

The eight rollers shown are made of extra heavy 1½-inch galvanized iron pipe and rest in roller bearings, as shown in one of the detailed sketches. The door and door frame should be true so that there will be no warped surface to shut against, thus insuring a snug fit when the door is closed.

An alternative method of forming the roof for the steam chamber is to carry up the corner angles 3 feet 6 inches high and make the roof flat instead of sloping. This is shown in one of the sketches in Plate 44. But in order to permit the condensed steam to trickle down the sides of the chamber and not drip on the products being hardened and so mark them while soft, a light galvanized hood is attached to the roof suspended therefrom by means of three light galvanized iron bolts, the lower ends of the hood being riveted to the sides. If this form of construction is used it will be necessary to bend the hood slightly out of shape so that it may pass through the door of the chamber for attaching in proper position, but being of light metal it may readily be bent back to proper shape and position after attached to the roof by the

suspension bolts. These bolts should be about 4 inches long and threaded their entire length. Four nuts will be required for each bolt—two to form shoulders, which will keep the hood at the required distance from the top of the chamber.

Lighter steel than No. 18 gage may be used for covering the chamber, but this weight is recommended because the steam will rust the metal and a lighter gage would therefore be less durable than the heavier one.

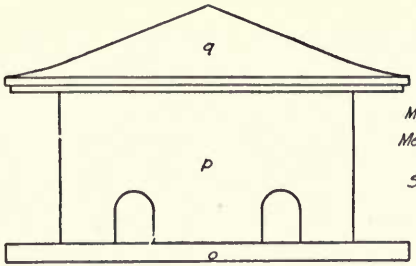
A concrete driveway from the street to the home garage at the back of the lot is many times better than a pair of ruts and a string of mudholes.

PLANS FOR FOUR-ROOM STUCCO BIRDHOUSE FOR MARTINS

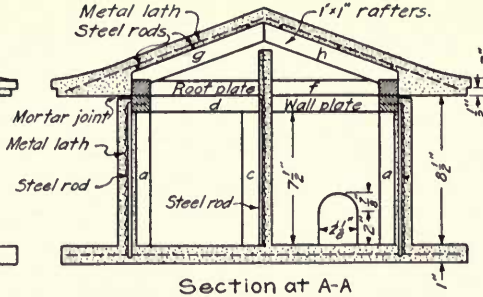
Plate 46 shows various details of a cement stucco bird house for martins. This house rests on a concrete floor or platform 22 inches square. The bird house itself consists of four rooms, making a structure 16 inches square. The various parts are the platform or floor, outer walls, roof and partitions. The platform, or floor, is built of a square piece of metal lath or expanded metal stuccoed, that is, plastered on both sides with cement mortar to a total thickness of 1 inch.

Four holes should be arranged for in this platform by inserting greased wood plugs into the mortar and through the metal lath while the plaster is soft, to receive the rods (r) at the corners of the house.

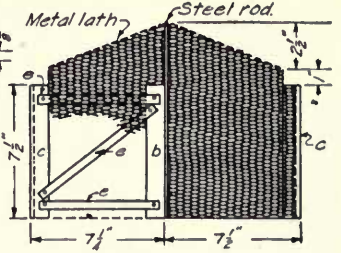
The outer walls are formed by first nailing together the wood uprights (a) and wall plates (d). These are shown in the plan at the lower left-hand side of the illustration and in the section at the upper center. These rods are stapled to the sides of the corner posts (a) as shown. Intermediate or side posts (c) and the center post (b) may be difficult to hold in proper position unless temporarily secured by means of stay laths (e) as shown in a portion of the partition in the upper right-hand sketch. After metal lath or expanded metal has been fastened to posts (c) and (d), the temporary stays (e) may be removed. Metal lath or expanded metal, which is the ground work of the partitions, is first cut to the desired size so that the upper edge when set up will be slightly below the roof. The outer walls are then set on the platform so that the four projecting rods (r) will be embedded in the holes previously provided for them. This prevents side movement of the frame while applying the cement mortar or stucco. Partition walls are placed inside the outer wall and the posts (c) nailed to wall plates (d). The exterior walls and partitions should then be plastered with cement stucco. Before applying the plaster to the exterior walls, small cores,



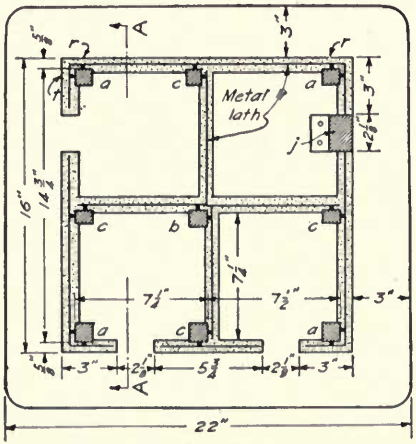
South Elevation.



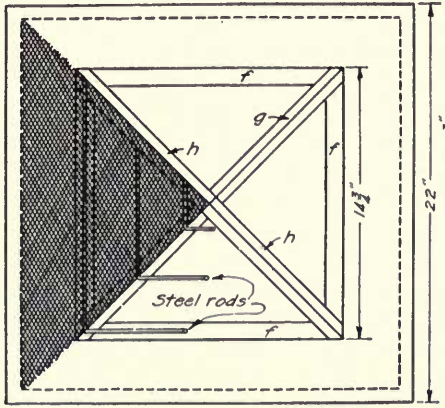
Section at A-A



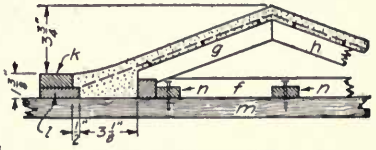
Partition c-b-c
Showing Metal Lath Attached.



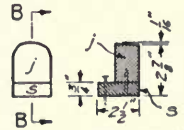
Plan.



Roof Plan
Showing Framing and Metal Lath.



Detail of Cornice and
Roof Construction.



Elevation Section B-B
Core for Entrance.

such as shown in the sketch at the lower right-hand of Plate 46, should be set in cut-outs previously made to provide entranceways to the various rooms.

The roof is composed of roof plate (f) shown in the plan at the lower center of Plate 46, and the hip rafters (g) and (h). After the rafters have been framed, they should be nailed together at the peak, and to the roof plate. Metal rods are then fastened to the upper surface of the rafters, as shown, following which metal lath or expanded metal cut to triangular shape is attached to the rods and rafters.

Various details of preparation for plastering the roof are shown in the center sketch at the extreme right-hand portion of Plate 46. Cement mortar is troweled into the metal lath or mesh. After the stucco has become thoroughly hard, the roof section is placed on top of the wall plates as shown and fastened to them either with clamps or wood screws, but first there is placed a bed of mortar at the top of the concrete surface and level with the top of wall plates. The walls are then set in a bed of mortar on the platform and the four rods (r) grouted into holes provided for them, that is, the rods are permanently set in these holes by pouring around the rods a thin cream-like mixture of cement and water.

This plan may be enlarged or otherwise modified without in any particular respect changing the essentials of the design. Any kind of metal fabric or expanded metal may be used. Other sizes of posts, rafters and wall plates may be substituted for the size shown.

Proportions and shapes of bird houses may vary, but the same principles of construction when concrete or stucco is used apply to all types.

Each bird house must be planned to meet the particular habits and characteristics of the species of bird for which it is intended.

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